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PROGRESS REPORT ON THE USE OF PETROLEUM OIL AS AN INSECTICIDAL SPRAY

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ABSTRACT

A summary of established field practices in the use of petroleum oil sprays for both citrus and deciduous trees is given to date, together with data covering the species of insects concerned and the dosages used for same.

Dormant spraying of deciduous trees during the past year has been almost free from complaints of injury due to the better physical condition of the trees and the type of oil commonly used. Spraying of citrus trees is still accompanied with reports of functional disturbances which in part, at least, are considered due to oils of too low volatility. This may be overcome by use of two types of oil of different volatilities. In addition to the sulfonation test, the oxidation rate of oils gives promise of being another specification of value in determining the safety to the plant. The incorporation of nicotine or other active insecticides directly into the oil before emulsifying offers the possibility of increasing the toxicity of the oil itself without increasing the danger to the plant.

The year of 1926-27 has shown a marked increase in the use of petroleum oils, having a high unsulfonatable residue, both on citrus and deciduous trees in foliage. The common practice in the citrus districts of California is to use a 2% emulsion, largely of the quick breaking type[1], on both lemon and orange trees as a control for black scale, *Saissetia oleae* Bernard, red scale, *Chrysomphalus aurantii* Maskell, the purple scale, *Lepidosaphes becki* (Newman), citricola scale, *Coccus pseudomagnoliarum* (Kuwana) and citrus red spider, *Paratetranychus pilosus* C. & F., in combination with nicotine sulfate for aphis. Dates of spraying vary with the species concerned and the locality while the concentration of oil in the emulsion ranges from 1 to 2%. Commercial emulsions are decidedly predominant. Of the oil being used, only a very small

[1]deOng, E. R., Hugh Knight, and Joseph C. Chamberlin (1927) "A Preliminary Study of Petroleum Oil as an Insecticide for Citrus Trees." Hilgardia (Calif. Exper. Sta.) 2:351-384.

amount is used as a home-made emulsion. Oil sprays have made very heavy inroads into the use of hydrocyanic acid gas for fumigation purposes although in the last year there has been the reverse tendency in some sections. This movement has been aided by the popularity of a combination fumigation and spraying program with but a few days interval between the two applications.

Foliage spraying of deciduous trees attained widespread proportions during the summer of 1926, principally as a control for the red spiders (*Tetranychus spp.*) This practice is most common on prunes, and to a less extent on almonds and Kadota figs. Such sprays are not satisfactory on shipping plums as the bloom is dissolved, thus impairing their apppearance. The same type of emulsion and oil is used as on citrus trees but largely at a concentration of 1 to 1.5%. Much satisfaction has been expressed by prune growers over this type of spray, while the expense of a dollar to a dollar and a half for 100 gallons of spray is not greater than most growers will pay. Oil sprays on apples and pears, as a substitute for lead arsenate, is receiving an extended trial both in California and the Pacific Northwest but as yet no standard practice has been adopted.

Dormant spraying of deciduous trees, largely with commercial emulsions, is very general as a control for brown apricot scale, *Lecanium corni* Bouché, and closely related species together with San Jose scale, *Aspidiotus perniciosus* Comst., Italian Pear Scale, *Epidiaspis piricola* Del G., and the egg stage of the brown mite, *Bryobia praetiosa* Koch, citrus mite, *Paratetranychus pilosus* C. & F., and of defoliating caterpillars. The concentration of oil in the emulsion ranges from 2 gallons in 100 for the Lecanium scales and red spider eggs to 3 to 6 gallons for the armoured scales and as high as 8 to 100 for the leaf roller eggs (*Archips argyrospila* Walker) in the Pacific Northwest.

Effect of Oil on the Tree.—The dormant spraying of deciduous trees during the winter of 1926-27 has been accompanied with fewer reports of injury, as noted by the author, than in any previous year where lubricating oil was generally used for spraying. This was apparently due first to the fact that abundant rains and the lack of dessicating winds placed the trees in a more resistant condition; second, the growing tendency among the manufacturers of oil emulsions to use a more highly refined stock,—the unsulfonatable residue ranging as high as 70%. The use of more highly refined oils for winter spraying is very desirable as a certain amount of the work is always done before complete dormancy in the fall or after the trees are beginning to grow in the spring at which times the tree is quite susceptible to injury.

Foliage spraying of deciduous trees, especially prune, almond and the fig and also on strawberries has occasioned almost no complaint. Some data has been accumulated indicating a reduction in the sugar content of prunes but this seems to be largely the result of very late spraying, when the fruit is beginning to ripen. This difficulty seems to be overcome by earlier spraying and the use of more volatile oils for late applications. There have been complaints of oil injury on apples in Oregon and Washington, but the author has not had a personal acquaintance with these.

The use of oil in citrus groves occasionally gives cause of complaint either to the tree or the fruit. This is not of an acute nature but rather a functional disturbance such as non-coloring of lemons, premature dropping of fruit, dearth of bloom and early decay of fruit in storage and transit. The validity of claims of damage of this nature are difficult to establish, but their persistence lends weight to the thought that there is ground for complaint. It is now generally conceded that a possible cause for this trouble is the use of oil which volatilizes too slowly and further study is being given to the selection of oils which will further minimize the possibility of injury. A cooperative attack on this problem is now in force between a number of Station and Federal entomologists, chemists and plant physiologists of the Pacific Coast and in this way it is believed that more rapid progress will be made than by each working on different types of oil.

TYPES OF OIL FOR SPRAYS.—The greatest progress in the development of petroleum oil for spraying has come thru the adoption of the sulfonation[2] test as a measure of safety to the plant. In addition to this criterion there should also be given the volatility factor as determined by evaporation, preferable below 100°C. while the distillation history is also of value as indicating the difference between "straight run" fractions and blends of oils of different constitution. The viscosity and the Baume is also usually given. Typical analyses made by the Chemistry Division of the California State Department of Agriculture of two foliage types of oils showing a wide range in their specifications is included:

	Unsulfonated Residue	Evaporation at 100° C.	Distillation Summary	Viscosity (Saybolt)	Baume
(a)	98–100%	34% in 42 hrs.	34% between 300°–350°C.	105–110	31
(b)	84–86%	83% in 42 hrs.	67% between 300°–350°C.	56–58	32

[2]Gray, G. P. and deOng, E. R. California Petroleum Insecticides. (1926). "Industrial and Engineering Chemistry" 18:175-178.

Comparing (a) with (b) it will be seen that the Baume or specific gravity is almost identical, yet they differ markedly in evaporation, distillation and viscosity. A study of these last three factors shows that oil (b) is a much more volatile oil than is (a), although the specific gravity does not indicate this. These two types of oil will serve to illustrate the range in types of oils sold as commercial insecticides. Some manufacturers are offering similar oils to the two types described as a possible solution of the difficulties mentioned as occurring particularly in citrus groves. This seems a logical step in progress for oils penetrate to a variable degree into the inter-cellular spaces of the leaf and fruit and possibly into the cell itself. Here the oil may remain[3] for a period ranging from days in the case of kerosenes to months or possibly years with lubricating oils of low volatility in citrus leaves. The presence of oil in the air spaces between the cells interferes with the free exchange of oxygen, carbon dioxide and moisture, and possibly causes other complications, therefore, if the residence of the oil in the tissue is prolonged there may be considerable interference with the normal functions. Hence the quicker oils evaporate the less risk there is to the plant.

A much higher per cent of sulfonatable material is found in oil (b) than in the less volatile form (a). This is in accord with the theory that a slightly higher degree of sulfonatable material may be present in the more volatile oils without necessarily increasing the danger to the plant.

The oxidation rate is still another factor which is receiving increased attention as an important criterion of the value of an oil. This factor has been recognized for a number of years as an important specification of lubricating oils. T. S. Sligh, Jr., states[4] that "Mineral oils have a tendency to combine with oxygen, especially at high temperatures, forming undesirable oxidation products in the oil. Oxidation is accompanied by a discoloration of the oil, an increase in its viscosity, the development of acidity and finally the formation of precipitates of an asphaltic nature. The factors affecting oxidation are, (1) instability of the oil, measured by its tendency to form oxidation products; (2) presence of catalyzers tending to accelerate oxidation; (3) severity of exposure of the sample to oxidizing conditions. This exposure is dependent upon the temperature, duration of test, and degree of contact between the oil and oxygen

[3]The presence of oil in the leaf itself is shown by darkened areas which appear more or less transparent by direct light or it may be located more exactly by microscopic examination of sections of leaves treated with stained oils.

[4]Sligh, T. S. Jr. "An Oxidation Method for measuring the Stability of Mineral Oils." (1924). Proceedings of Amer. Soc. Testing Materials. Vol. 24, Pt. II, Philadelphia, Penn.

during the test." Besides the above factors it should be noted that sunshine (a factor present in field work but not usually presented in laboratory tests, unless stimulated by violet ray) is considered to be important in calculating the rate of oxidation. We should not, of course, attach too much importance to the comparison of laboratory data (accumulated under artificial conditions) to those of field data, but experiments have already shown that oils exposed to standard laboratory methods of oxidation have given increased foliage injury in proportion to the amount of acidity developed. The latter factor is apparently of more importance than the development of sludge precipitate. Limited experiments have shown that certain oils containing a very high amount of unsulfonatable residue may oxidize more quickly than others containing large per cents of materials which will combine with sulfuric acid. Should further work confirm these findings, then it would be advisable to include oxidation "rate" or "number", whichever it may be specified, together with sulfonation as a further aid to evaluating an oil.

COMBINING ACTIVE INSECTICIDES WITH OIL.—It has been shown[5] that the most highly refined petroleum oils have lost their most toxic insecticidal qualities and that complete kills of resistant scale insects is possible only by prolonged exposure, presumably through tracheal penetration, to oils volatilizing rather slowly. Such oils have been found to be subject to criticism from the standpoint of plant tolerance, while volatile oils such as kerosene, may be safer on the plant, but are not satisfactory scalecides. This leads to a study of the possibility of incorporating more toxic materials such as nicotine in the oil itself and emulsifying the latter as usual. Experiments on the brown apricot scale (*Lecanium corni*) with kerosenes containing small amounts of the alkaloidal nicotine, "free nicotine", have shown a decided increase in toxicity with but little if any difference in the degree of plant tolerance. A study of this matter offers the possibility of greatly increasing the toxic effect of oil, and at the same time retaining its penetrating qualities and wax solubility while the dangers resulting from too long a persistence of the oil in the plant tissue may be overcome by using more volatile fractions. Further work is now being done on this subject in the development of oil soluble nicotine salts which may be incorporated in the oil before emulsification.

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[5]Opp. Citation, deOng et al. Petroleum as an Insecticide.

THE USE OF OIL SPRAYS ON CITRUS DURING 1926

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ABSTRACT

Highly refined oil sprays were quite extensively used on citrus in California during 1926. Scale kill was quite satisfactory with some materials. Various injurious influences were sometimes noticed, such as retarded coloration, reduced crop and impaired quality. Avoidance of such injury has been attempted by particular attention to application, strength and fruit picks. Combination spray-fumigation is the most successful way of controlling resistant scales.

The use of oil sprays on citrus in California has been developing with great rapidity within the past few years. In order to encourage and stimulate this development along sound lines the Bureau of Pest Control of the California Fruit Growers Exchange has for 4 years been making a comparative field study of the commercial results of all insecticides used on citrus, particularly of sprays as compared with fumigation. Some of the outstanding developments of the past year are herewith presented in brief.

Several new oil emulsions of the highly refined lubricating type have been used on citrus. Most of these oils are generally high in unsulfonated residue but differ somewhat in viscosity and specific gravity. There appears to be a marked difference between the oils in the rapidity with which the oil film disappears from the tree. The speed with which the oil film disappears is reflected in scale kill as well as certain types of the injury. Some oils with the most lasting film requires several weeks before full effect on scale insects is determinable. Other oils less lasting but apparently more penetrating or with more toxic properties kill scale within a few days. The more smothering type of oil coating which remains long on the trees appears at certain times of the year, particularly the autumn, to exert an influence on bloosoming the following spring. This point was first brought out by the writer in 1926. This past year the reduction in blossoming has been equally apparent with that of a year ago in the case of certain sprays. Furthermore, it appears that certain oils which in one application have little effect on blossom reduction might have a considerable effect if twice applied the same season.

Although there was considerable retardation in the coloring of oranges in 1925-26 and influence on the coloring of lemons from certain oil sprays this injury has been little observed the past year. The trouble in 1925-26 arose largely from autumn and winter spray applications. The past year most oil spraying has been done in summer when fruit was of small size. Lemon picks were delayed for several weeks following the spraying.

This attempt to avoid cold weather spraying has reduced injury to a minimum. In addition to retarded coloration, heavy winter applications of oils which left a film of long duration sometimes also led to a softening of the fruit, puffiness and rough or pebbly appearance. It was also noted that in certain heavy sprayed orchards the fruit which was not picked until late summer the flavor was materially changed over that of fumigated fruit.

The scale kill on glossy surfaces such as leaves and fruit was superior to that on the wood with some of these highly refined lubricating oil sprays.

The combination treatment of an oil spray followed within a few days by fumigation, first used on citrus last year for resistant red scale, was continued with excellent results. Of upwards of 50 orchards examined following the double treatment only one fell below a 98 per cent kill. The oil spray is most effective on the fruit and leaves while the fumigation is best on the wood, therefore the combination works well. Oil appears to loosen the scale even when not destroying it and the fumigation is applied while in this condition. Furthermore, the oil appears to protect the trees so as to reduce the fumigation injury. Of upwards of 50 orchards double treated, only two showed any considerable fumigation injury although applied during a year of generally severe injury from fumigation. The time of application influences the period during which red scale is held in commercial control. Late August and September work is decidedly more lasting than July treatments.

The citrus red spider is a common pest of citrus. The control of this pest by the use of oil sprays varied both with the type of oil used and the time of application. Certain sprays gave temporary control but the spider returned within a few months. Other sprays appeared to give control for almost a year. The month of application influenced the permanency of results greatly. In certain orchards sprayed in July with good results the spider returned the following spring. Others in which the time of application was September carried through for the entire year.

SIGNIFICANCE OF MID-SEASON UNITS COUNTS ON RESISTANT BLACK SCALE

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ABSTRACT

In the resistant black scale area in the citrus belt of Southern California, where the "unit system" is used to determine the degree of scale infestation, it has been applied only to mature scale in the spring. No method, other than one of estimation, has been used to determine this at any other season of the year. The writers have carried on observations throughout the past season to secure data on the significance of units counts on immature scale. Their methods and observations are recorded herewith.

INTRODUCTION

Of the various scale insects attacking citrus in Southern California, the black scale (*Saissetia oleae* Bern.) is the most important from an economic standpoint. In the 1926-27 season approximately 60,000 acres of citrus in California were fumigated and about the same amount sprayed. Of this, 40,000 acres were fumigated and 30,000 sprayed primarily for the control of black scale. In other words approximately $1,500,000.00 was spent by the citrus growers of Southern California in an attempt to control black scale. Until about 15 years ago, fumigation was extremely effective as a control for black scale in all sections, but at that time it was observed that in a few orchards in the Covina Valley of Los Angeles County, satisfactory control was not obtained. Since then, this area, where unsatisfactory results obtained, has extended gradually year by year until now it covers almost the entire inland citrus belt of Los Angeles County and the eastern portion of the San Bernardino County, a territory some thirty to thirty-five miles in length with about 40,000 acres of citrus. The outlines are each year spreading until now it is impossible to foretell what the future status of this insect may become.

Apparently a strain of black scale has been developed that is more or less immune from or resistant to hydrocyanic acid gas. To date no theory as to the cause of this phenomenon has been generally accepted, although the tendency is toward an hereditary immunity being built up. The scale in this area is generally spoken of as "resistant" black scale and the particular district in question as the "resistant" area.

In this resistant area it is not uncommon to observe groves with a 75% to 90% crop reduction due to the effect of the scale during a single season. Many growers endeavoring to control the scale have spent much time and money and have suffered severe crop losses through unsuccessful control measures.

With the 1926 fumigation season, the California Cyanide Company introduced anew feature in insect pest control, namely: "Guaranteed Pest Control." A commercial kill of the particular insect pest for which the fumigation was applied was guaranteed, the same being described "as one satisfactory to the Horticultural Commissioner, or his authorized deputy, of the County wherein the property fumigated is located." In this area where more than one treatment is frequently necessary, an important factor is to determine soon after treatment whether a second is needed in order to secure control of the scale. There is no standard method to determine this condition. In fact the method generally practiced to determine the degree of infestation is one of estimation. It is true a keen observer, thoroughly experienced in a certain locality, can oftentimes decide if a grove will require further treatment. Many, however, are not qualified to give dependable decisions. The fault, considering all concerned, is the tendency to avoid a close decision and, if the issue is doubtful, to indicate further treatment. No system wherein actual figures are used has been established for mid-season observations. In Los Angeles County a system based on estimation is used. This work is carried on primarily as a basis for the recommendation of treatments for the following season and secondarily for the comparison of results obatined by the use of various insecticides. The Bureau of Pest Control of the California Fruit Growers' Exchange use a method of "unit counts" as a means of comparing the efficiency of various insecticides. In this method[1] scale-bearing twigs six to ten inches long are picked from the north side of the tree and the number of living scale counted. Enough twigs are examined to typify the scale condition of the tree and the average number of scale found is computed. This then gives a figure that is comparable with figures from other groves where twigs are similarly chosen. This past season the Los Angeles County Horticultural Commissioner used a similar system of unit counts in conjunction with the estimation system, primarily as a check to establish more uniformity in the inspector's results.

This system has been applied only in the spring after the scale have migrated from the leaves onto the twigs and have become mature. For purposes of determining whether further treatment is needed for control of the scale, it is necessary to have some basis of estimating the degree of infestation during the fall and early winter. The unit system has been used heretofore entirely for spring inspections. The writers this past fall began observations on several orchards scattered throughout

[1]Woglum, R. S. "The Values of Sprays and Fumigation for Resistant Black Scale Control." Bulletin, California Fruit Growers Exchange, July 1925.

the resistant area in an attempt to obtain figures as to scale infestations on a unit system which could be applied to immature scale.

Any system must be applicable to all varieties of citrus and it must be consistent in its application to groves treated with different materials or methods. It must of necessity be simple or at least capable of being applied by different persons. It is felt by some that it requires too much time to ascertain the condition of a grove by unit counts. It is felt by others, however, that if a portion of a crop or the cost of a treatment rests with the decision, a reasonable amount of time is justifiable. Still others take the stand that a method must of necessity be simple only in that uniformity may be established among investigators and officials upon the application of a reasonable amount of time.

In this work units were selected from trees on the two diagonals across the orchards and rows across both ends. As the work progressed it was found to be unnecessary to select units from trees across the ends as the two diagonals gave comparative results. It was further observed that, in the early season, units selected from every other tree on the diagonals gave averages comparable to those from units selected from every tree. However, as the season progressed there was greater variation in type of units, so units were then selected from every tree.

It is in the selection of the units that the greatest opportunity for variability appears. A thorough knowledge of the botany and growing habits of citrus trees is absolutely necessary. Placement of scale upon the tree not only varies with different districts but also with individual groves. This variation is influenced by fertilization, pruning and cultural methods and increases as the season advances and more new growth appears. In June and early July after the scale hatch, and until the next period of new growth appears, sometime in mid-summer, the scale are to be found on foliage and wood throughout the tree. Units are easily selected with excellent uniformity at this time. Later a third period of growth appears, more or less sheltering the mid-summer growth which becomes infested with young scale. This third period of growth is irregular in appearance and is followed by other growths as the season advances. Because of the variation of these growths in the different orchards, it is very easy to select units which are not typical of the infestation. The investigator can select satisfactory units only by carefully judging the placement of the scale before commencing his selection.

On counts made during October, November and December, when the majority of the scale are on the foliage, great care must be exercised in the size of the units and in the number and size of the leaves on the units

chosen. In this work binoculars were used to examine both the foliage and the wood until in the spring when the scale were well grown. All questionable scale were punctured with a needle. Each leaf was severed from the unit after examination and before commencing another thus making it easier to see the scale. To expedite the work of the counts, a record was kept of 16 groves to determine if it was necessary to examine the under sides of the leaves for scale. The results of these examinations (Table 1) point out that it is not necessary to examine the under portion of the leaf. In none of the groves does the number of scale on the bottom of the leaf affect the final figure of the count sufficiently to justify the time of making the examination.

TABLE 1. PROPORTION OF SCALE ON BOTTOM OF LEAF

No. of scale per unit	No. of scale per unit on bottom of leaf	Percent of scale on bottom of leaf
.55	0.	0.
.94	.055	5.8
3.2	.16	5.
1.0	.04	4.
2.4	.266	1.08
2.92	.095	3.2
17.78	1.04	5.85
.79	.04	5.06
1.00	.033	3.3
1.22	.04	3.27
2.27	.22	9.69
2.46	.06	2.43
2.78	0.0	0.
1.00	0.0	0.
2.26	.034	1.5
6.05	.066	1.09

MORTALITY

As the season advanced successive counts on several groves indicated that the method of counting was dependable. However, the application of the figures obtained to commercial control was questionable. No records existed on the mortality of the scale in this district. The counts indicated that a large natural mortality was taking place. This mortality was either a normal condition or was influenced by one or more of the following elements; precipitation, wind, temperature and parasitism.

A comparison of the monthly percentages of mortality (Figure 33) with the precipitation (Figure 34) does not indicate any unusual influence on the mortality of the scale. The low month, January, with .95 inches of

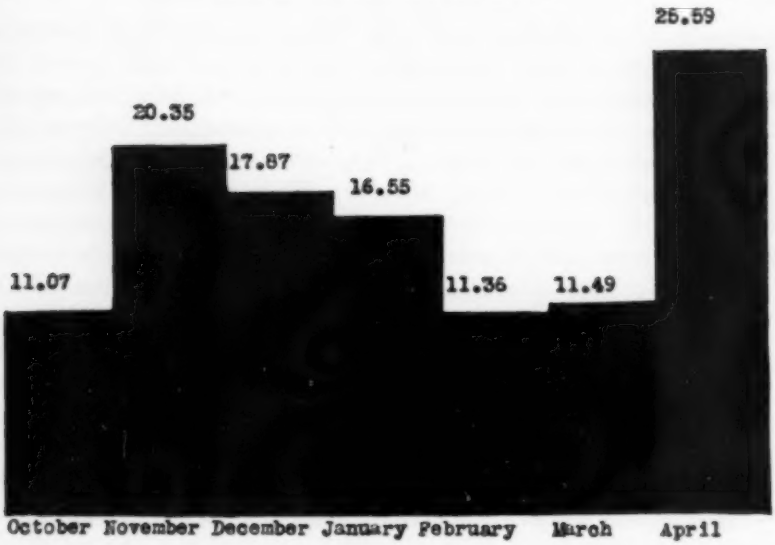

FIG. 33.—Average monthly percentage of mortality, October 1926–May 1927.

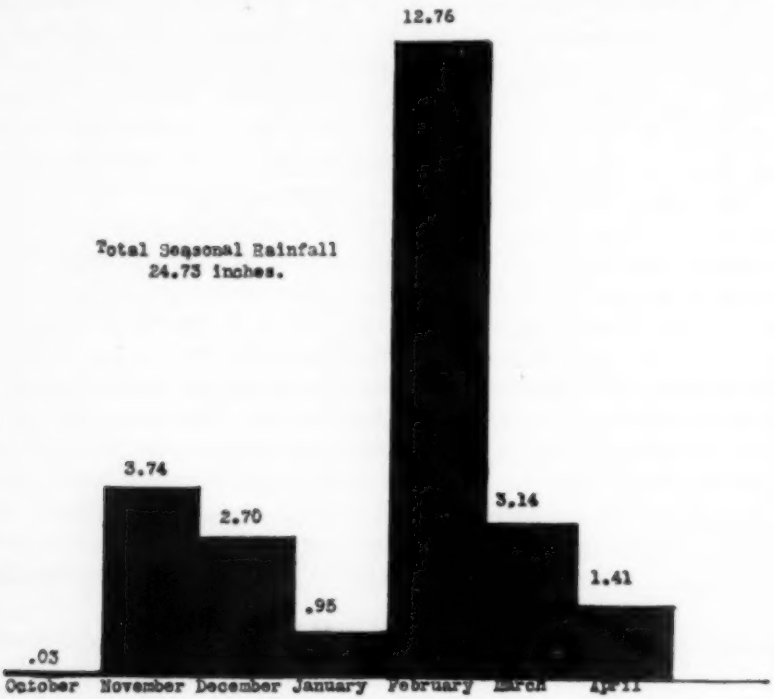

FIG. 34.—Monthly rainfall, Pomona, California, October 1926–May 1927.

rain and the high month, February, with 12.76 inches apparently show no particular influence on the mortality. A close check of the individual inspections of the groves shows no connection with excessive rain fall.

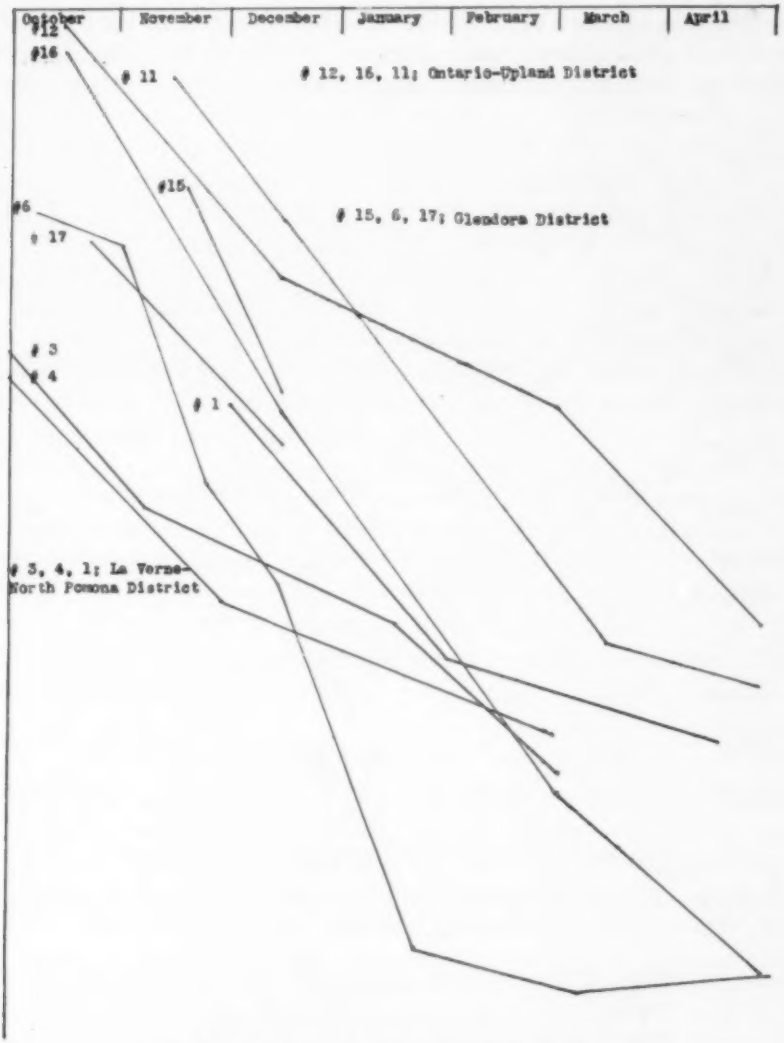

FIG. 35.—Individual orchard mortality curves.

A severe north wind the early part of December caused a heavy defoliation of trees in groves located in the Glendora and Ontario Uplands districts. This defoliation removed large numbers of leaves bearing

living scale, particularly on the north sides of the trees where the majority of the scale are found. This condition influenced the counts somewhat, although an effort was made in later counts to select units bearing the old foliage. In Figure 35, the mortality in groves located in the Glendora and the Ontario-Uplands districts is compared with that in groves located in the LaVerne-North Pomona district which is between the Glendora and the Ontario-Upland district. The LaVerne-North

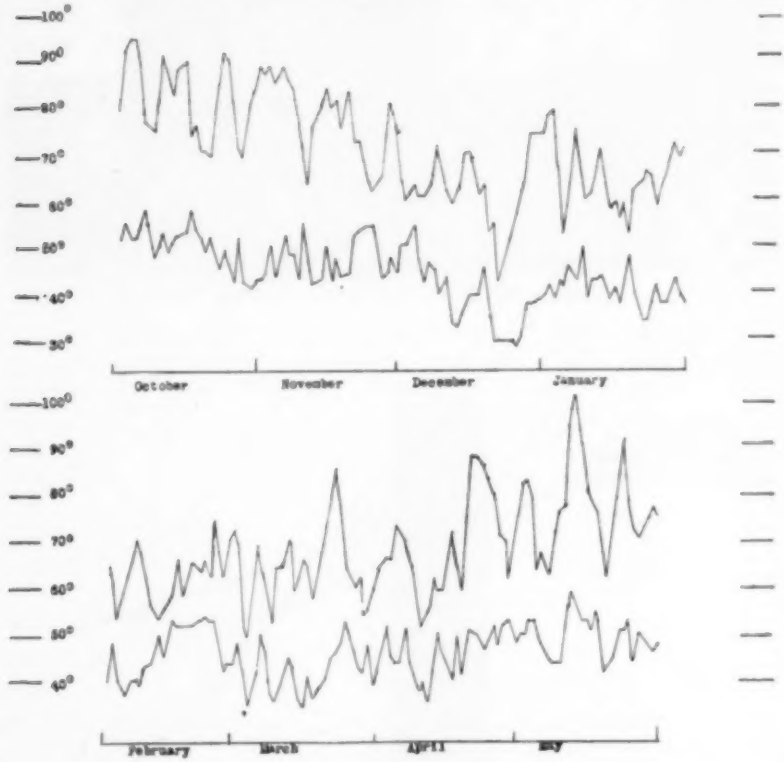

FIG. 36.—Daily maximum and minimum temperatures, Pomona, California, October 1926–May 1927.

Pomona groves did not receive the defoliation of the other districts Groves 12, 16 and 11 in the Ontario-Upland district showed an average mortality of 84%, while groves 3, 4 and 1 in the LaVerne-North Pomona district showed a mortality of 61%. For this comparison the groves in the Glendora district, groves 15, 6 and 17, could not be used as records were not kept for the entire season. The tendency of curves, however, is to bear out the conditions in the Ontario-Upland district.

Excessively high temperatures are responsible for a high percentage of mortality. This is especially true in the early summer when the scale are just hatching or are still in the first or second instar. A week in June, 1917, with maximum temperatures each day from 99° F. to 117° F. brought about an extremely effective control of the black scale in the interior districts of Southern California. Ordinarily during June and July there is a mortality in the young scale ranging upwards from 50% due largely to high temperatures. However, the scale increases in size as the season advances and is, therefore, less apt to be affected by high temperatures. After August it is doubtful if temperatures under 100° F. have any effect on scale mortality. October 1926 and May 1927 are the only months (Figure 36) having temperatures over 90° F. The temperatures in May are, of course, irrelevant as the scale are mostly in the rubber stage or mature and ovipositing. The average mortality of 7 groves covering a period from October until December was 37.02%. This compared with a mortality of 46.88% during the period of January to May. This apparently indicates that the temperatures of October were not sufficiently high to affect the scale.

One parasite (*Aphycus luteolus* Timb.) could be said to influence the counts. The work of this parasite was very general and in some groves of considerable importance in killing immature scale. The counts in late spring revealed larvae of *Aphycus lounsburyi* Howard and *Scutellista cyanea* Mots. These parasites very seldom affect the commercial condition of lightly infested groves except when in close proximity to those heavily infested. Many predators were observed but none in sufficient quantities to influence the counts.

Migration

The average monthly percentage of total migration is shown in Figure 37. The migration is quite gradual from October until February, less than 15% of the scale migrating each month. In March and April approximately 50% of the scale migrates. Comparing this with Figure 33 it will be observed that the mortality approximates very closely the migration. Following the greatest period of migration appears the greatest loss in scale numbers or in other words the greatest mortality is found following the period of greatest migration.

Off-Hatch

The area under consideration in this investigation is definitely an even hatch area. There seems to be a tendency, however, in many

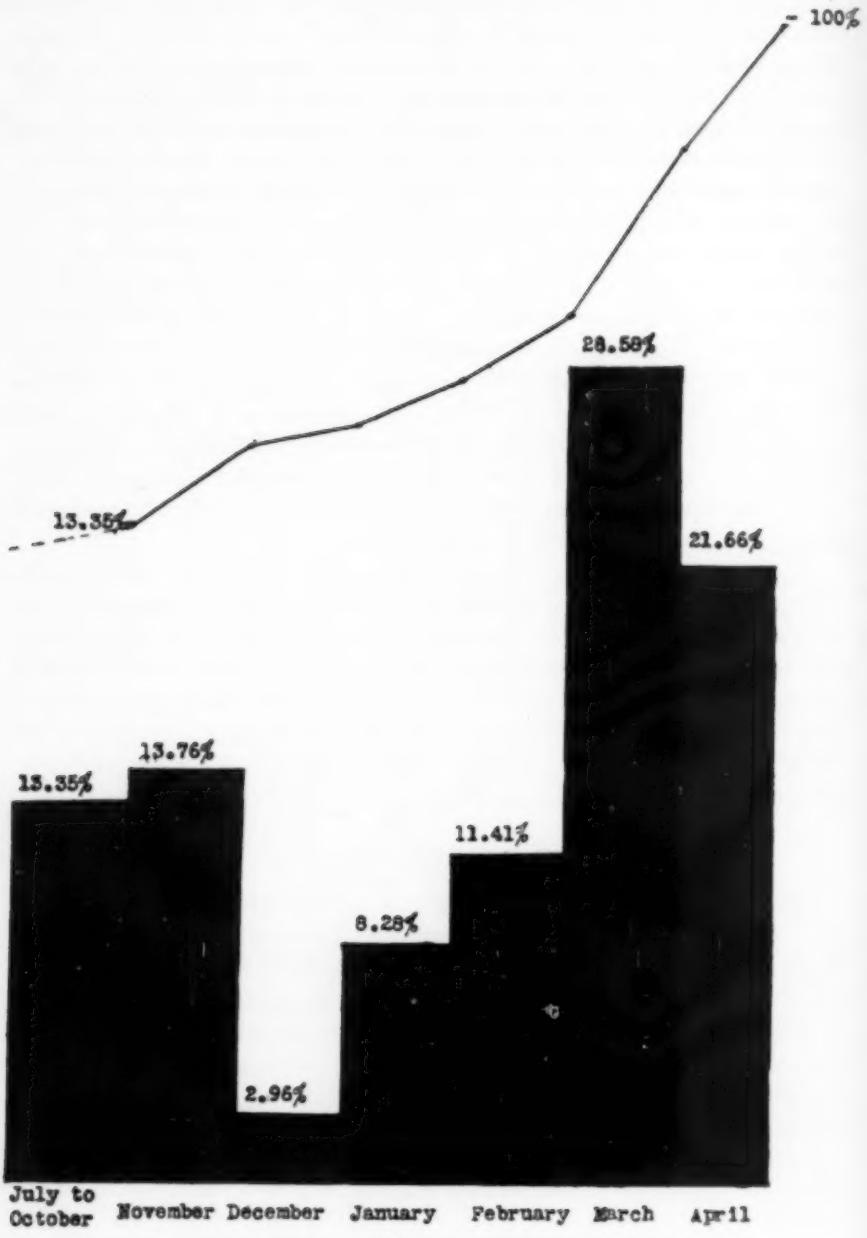

FIG. 37.—Average monthly percentage of scale migration.

groves for the scale to attain an uneven size. This condition is intensified in groves which have been improperly sprayed and in groves where the infestation is very heavy. Groves inefficiently sprayed and groves fumigated with liquid HCN at low temperatures show a larger proportion of the remaining scale in the tops of the trees. These scale, located in the warmer portions of the trees, are prone to mature more quickly, thus creating an off-hatch condition. During every month of the period covered in this investigation scale were found to be hatching. In seven groves which showed off-hatch during the season there was an average mortality of 49.98% as compared with an average mortality of 75.87% in eight groves not showing off-hatch. This indicates the importance of an off-hatch condition.

Ryan and Woglum in their methods of counts, using similarly sized units, state that any grove having an average of 1.5 mature scale per unit is commercially clean. The average per cent of mortality this past season including groves with an off-hatch condition was 63.73%. Since all applications of counts were made after October 1st, it would appear that if in a particular orchard there were 4.13 scale per unit present on October 1st, through natural mortality the chances are that by spring, and maturity of the scale, there would be but 1.5 per unit left. Of the seven orchards under observation (Table 2) where there were more than 1.5 live scale per unit in October or November and where no off-hatch appeared to off-set the natural mortality, six showed 1.5 scale per unit or less at the spring inspection. While there were not many groves with early inspections, these figures indicate that a grove showing less than 5 scale per unit in October will by natural causes be commercially clean at the maturity of the scale.

TABLE 2. CORRELATED FALL AND SPRING UNIT COUNTS

Grove No.	Month Inspected	No. scale per unit	No. scale per unit in Spring	Commercially clean
4	October	2.70	1.13	yes
5	October	5.43	2.44	no
8	November	4.97	1.5	yes
9	November	2.4	.62	yes
11	October	3.04	.48	yes
12	October	4.08	1.0	yes
14	October	3.08	.3	yes

SUMMARY

The absence of an accurate method for determining the degree of infestation has caused many losses, because of improper advice. All unit

counts made prior to the 1926-27 season were for the purpose of comparing materials or methods of control and were made in the spring on mature scale. Observations in this investigation were commenced in the fall and continued until the scale were mature or until the grove was retreated.

A twig six to ten inches in length bearing eight to twelve leaves was chosen from alternate trees in alternate rows and from the ends. Later units selected from each tree on the diagonal gave similar results. Until the scale were at least half grown, binoculars were used on all counts.

Considering all the elements, precipitation, wind, temperature and parasites, none seemed to have any unusual effect upon the mortality except the wind in certain districts. Off-hatch scale affect the counts made before October and possibly in some groves after this period. This can usually be determined by the investigator in an inspection of the tops of the trees, and thus avoid a discrepancy. The junior writer made all counts personally, therefore, it may be necessary to increase the number of units chosen from the individual tree in order to decrease the probability of error, if this method of unit counts is to be generally used.

The figures indicate that orchards where counts made prior to October show less than 5.0 scale per unit were commercially clean by the maturity of the scale in June. Similar observations must, of course, be carried on for several successive seasons before any definite degree of normal mortality can be stated.

BEET LEAFHOPPER, *EUTETTIX TENELLUS* (BAKER) DOES NOT OCCUR IN THE ARGENTINE REPUBLIC

By HENRY H. P. SEVERIN, Ph.D., *California Agricultural Experiment Station* and CHARLES F. HENDERSON, B. S., *California Agricultural Experiment Station* and *U. S. D. A. Bureau of Entomology*

According to Boncquet (1) the beet leafhopper, *Eutettix tenellus* (Baker) has been found in the vicinity of "Buenos Aires, in Guatrache, Alpachiri and Bahia Blanca (South-East), in Colonia Alvear and Mendoza (West) covering the major part of the temperate and sub-tropical zones of the Argentine Republic." Leafhoppers which were reported to have been collected at San Isidro, a suburb of Buenos Aires, were determined as *Eutettix tenellus* (Baker) by E. P. Van Duzee and Severin, and are in the collections of the California Academy of Sciences.

Henderson who was sent to Argentina to introduce parasites of the beet leafhopper into the United States failed to find *E. tenellus* in any of

the localities in which Boncquet stated that it occurred. During the exploration from November 11, 1926, to June 30, 1927, the most favorable host plants of the beet leafhopper were swept with an insect-net in the same and many other localities. Insect collections in museums and of entomologists were examined, but not a single specimen of *E. tenellus* was found.

The following question has been asked by a number of scientists: If the beet leafhopper does not occur in Argentina, how do you explain the fact that Boncquet submitted *E. tenellus* for determination from that country? In a letter dated June 14, with permission to quote, Boncquet states that *E. tenellus*, preserved in a bottle of alcohol, was taken from the United States to Argentina, and that collections of leafhoppers preserved in formaldehyde were made in various localities in the Argentine Republic and the Panama Canal Zone. He writes, "The various sample bottles were identified by marks made on the stoppers; the possible mixing of the stoppers is only manner in which I can explain the confusion."

Boncquet admits that he is not acquainted with the specific characters of *E. tenellus* and his determination of the species hinges on "general appearance." An undetermined species of *Eutettix* resembling the general shape and size of *E. tenellus* was collected by Henderson on sugar beets, garden or red beets, and Swiss chard, in every locality in which Boncquet reported that *E. tenellus* occurred except in Guatrache.

In 1925, Fawcett (2) published a paper stating that *Aceratogallia sanguinolenta* transmits a disease in Argentina similar to curly-top of sugar beets except that the blackened concentric rings which alternate with light areas in a cross section of a beet root affected with curly-top are absent. The darkened phloem areas of the fibro-vascular bundles, however, are not a reliable and constant symptom of curly-top.

Fawcett received his determination from W. L. McAtee who in a letter to Severin dated April 19, 1926, stated that the Argentine leafhopper was a species of *Aceratogallia* and resembled the dark specimens of *sanguinolenta*. "My expression 'dark variety' became 'obscure variety' in translating."

During the past ten years a large number of tests have been made with many different species of leafhoppers, among them *A. sanguinolenta*, but *E. tenellus* is the only species which has been found so far to transmit curly-top. A letter dated April 6, was written to Fawcett calling his attention to the fact that *A. sanguinolenta* failed to transmit curly-top to sugar beets in California.

Fawcett sent to Severin specimens of *Aceratogallia* which his experiments have shown transmitted the disease to sugar beets. These leaf-

hoppers were sent to H. Osborn, E. D. Ball, and E. P. Van Duzee for determination. Osborn had already received some specimens direct from Fawcett. The species was identified as *A. sticticollis*. Ball writes, "Of Stal species, *sticticollis* comes nearest to fitting the species." Fawcett (3) in a later paper adopted the specific determination of Osborn.

Experiments were conducted to determine whether non-infective *E. tenellus* could transmit curly-top to healthy sugar beets after feeding on beets infected by *A. sticticollis*. Fawcett kindly sent two shipments of diseased beets which had been infected by *A. sticticollis*. The beet roots from the first shipment failed to develop leaves and those of the second shipment were decayed. Two hundred and fifty non-infective *E. tenellus* were fed on three beet roots which had been infected by *A. sticticollis*. The *E. tenellus* were then transferred to healthy beet seedlings, but not a single case of curly-top developed. No importance can be attached to this experiment, however, since the virus may have been destroyed by the souring of the juice.

Henderson, upon his return from Argentina, left at Washington specimens of diseased Swiss chard taken from a vegetable garden at San Isidro. This material has been placed in the hands of E. W. Brandes who turned it over to E. Carsner for experimentation.

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IMPORTANT COTTON INSECTS OF CENTRAL PERU

By W. E. HINDS, *Entomologist, Louisiana Experiment Station*

ABSTRACT

During a six weeks investigation of cotton insect problems in the Canete Valley, located about 100 miles south of the city of Lima, in central Peru, no evidence was found of the existence in Peru of either the Mexican cotton boll weevil or the pink boll worm. The Peruvian square weevil was found in nearly all fields examined and ranged from sea level to an altitude of over 2,000 feet. This species attacks only small cotton squares and causes them to flare and fall to the ground as do the squares attacked by the boll weevil. The square weevil is a small species, adults measuring from 2.5 to 4 mm. in length. The color is light tan or brownish but the integument under the scale covering is brown. The adults are extremely active and shy and are hard to find in the field but the flaring and falling of squares betray their presence. Usually only six or eight punctured squares occur on a plant but sometimes as many as twenty-five were found, these being apparently the work of one female. The development requires some sixteen or eighteen days and the larvae and pupae in fallen squares appear to be quite resistant to heat and drought. It is not known whether the species can survive freezing temperature during its hibernation period.

The most serious cotton pest in Peru seems to be a species of leaf worm. (Possibly more than one species is involved.) This species appears to be native and occurs abundantly every year, requiring usually three poison applications during the season. At least four generations of this leaf worm must occur. The observations made indicated a developmental period of from twenty-two to thirty days. The multiplication is rapid in spite of the presence of a number of species of predators and parasites. The usual method of control has been arsenate of lead or calcium arsenate sprays applied by knapsack spray pumps carried by Indian workmen. These spraying squads often numbering over 100 men, do nothing else for three months but spray for leaf worm control. Their work is very inefficient. Dusting has been started to replace the spraying and has given much better control of the worms with a very great saving in the time and labor of application. The climatic conditions and the topography of the irrigated valleys are ideal for airplane dusting work and such work is being started this season in Peru.

Other important insects include several species of small caterpillars which bore into the developing bolls. Their work is followed by the spread of fungus diseases which complete the destruction of the bolls. By this combined attack a damage of from 20% to 25% of the crop is frequently experienced.

GENERAL AGRICULTURAL CONSIDERATIONS

At the request of a group of Peruvian cotton growers, the writer made a brief study of the most important cotton insect pests and cotton production problems in a section about one hundred (100) miles south of the City of Lima, the capital of Peru. The particular section studied is known as the Canete Valley, but some observations made in other valleys both north and south of the Canete Valley indicated that the principal cotton pests were common to at least the central section of

Peru. In contrast to the situation of the Cotton Belt in the United States, which is a broad band about three hundred (300) miles wide and extending eastward and westward between approximately thirty and thirty-five degrees (30° and 35°) north latitude, the culture of cotton on the western coast of South America is confined practically to a very narrow strip close to the ocean but extending from about five to twenty degrees (5° to 20°) south latitude. This represents a coast line distance of nearly fifteen hundred (1500) miles extending from a northwesterly to southeasterly direction.

Throughout this distance the production of cotton and most other cultivated crops including particularly sugarcane, rice, etc., is confined very closely to the irrigable valleys. Rains occur only in the northern part of Peru and in the mountain ranges at elevations above three thousand (3,000) feet. Many small valleys with only a short drainage slope above them receive water only once in two or three years, but it is amazing how the people make use of this scanty and irregular supply and produce a succession of crops. In the larger valleys where streams rise high up in the mountains, the water supply may be more than sufficient to meet all requirements for irrigation. The principal streams running down the very steep slope of the Andes fall from a height of from sixteen to twenty thousand (16,000 to 20,000) feet to sea level within a distance of from one hundred (100) to one hundred and fifty (150) miles. The force of water coming down these narrow valleys is almost irresistible, but near their mouths the valleys widen out as the streams have washed back and forth across them, forming rather level valleys in which irrigation can be practiced with field crops.

In these irrigated valleys most of the land is held by a comparatively few companies, estates, or large individual owners. There are comparatively few "small farmers." The agricultural practices are often primitive, but in many cases very progressive. The work of plowing and of cultivation is done principally with oxen, altho mules are now being tried on a small scale. Fertilization consists in applications of the native Peruvian Guano which is gathered on the Coastal Islands especially and of nitrate of soda coming from the mines which formerly belonged to Peru. The irrigation water is controlled very carefully so as to check the growth of weeds and to promote the growth and fruiting of the cotton plants at critical periods.

The principal variety of cotton grown in the central Peruvian valleys is known as Tanguis. This appears to have originated as a natural hybrid between some Egyptian type and an American upland type of cotton. The dominant characteristics are Egyptian. The original

selection was made by Sr. Fermin Tanguis, and he has continued mass selection work more or less systematically during the past twelve or fourteen years. This variety now appears to be entirely wilt resistant and is a good strong growing and fairly closely fruiting plant. The type of growth during the first year after planting is quite erect but with two or three heavy vegetative branches near the base where the spacing is wide. Such stalks bearing more than one hundred and fifty (150) matured bolls are common. As many as 420 mature bolls have been produced on a single stalk of stubble cotton.

In Peru under tropical climatic conditions, with winter temperatures rarely falling below fifty degrees (50°F.), the cotton roots are not killed. Therefore after the crop is harvested, the stalks are cut back close to the surface of the ground. At the proper season the irrigation water is turned on and new growth starts. The crop thus produced from new sprouts may equal that of the first season from planting, and from three to seven successive crops may be grown in this way from one planting of seed.

During the field studies and from conferences with planters from widely separated sections, we found no evidence of the occurrence of the Mexican cotton boll weevil (*Anthonomus grandis* Boh.) or of the pink boll worm (*Pectinophora gossypiella* Saund.) which are generally considered as being the two most serious insect enemies of cotton.

Cotton Leaf Worms

However, Peru is not without its fair share of cotton pests. The most serious species found was undoubtedly one of the cotton leaf worms which has been determined for me by Dr. William Schaus as being *Anomis impasta* Guen. It is quite possible that two species of the genus Anomis occur on cotton in Peru, as local Entomologists identified the species as *Anomis luridula* Guen. In any case these leaf worms appear to be native species, widely distributed and now so well established that stripping of foliage is expected each season and the worms require treatment through a period of about three months. In the northern part of Peru our common species of leaf worm, *Alabama argillacea*, is reported as occurring also.

The genus Anomis is very closely related to Alabama. As might be expected, therefore, the general facts of life history, etc., appear to be very similar. Such observations as were possible on *Anomis impasta* indicated an egg stage of about three to five days; larval stage twelve to fifteen days and pupal stage seven to ten days. The total developmental period covering twenty-two to thirty days, as a rule, is quite similar to

that for *Alabama argillacea* in the Cotton Belt. Portions of two generations were observed between February 20 and March 20, 1926. Reports from growers indicate the occurrence of four or more generations during the season in the same locality. This impression is confirmed also by the general practice of making three poison applications for the control of these worms. The attack appears to be rather concentrated upon late-planted, tender cotton. The species was found distributed from sea level to an elevation of more than two thousand (2,000) feet.

This native leaf worm species appears to have a number of predaceous and of parasitic enemies. These help to check the multiplication but are not effective enough to render poisoning unnecessary. The general poisoning practice which has prevailed for many years consists in the use of knapsack spray pumps, operated by Indians who do nothing else for a period of three months but apply this spray of arsenate of lead or calcium arsenate. The spraying done was very slow and unsatisfactory. The tops of the plants particularly where they exceeded four feet in height were never thoroughly covered. Therefore, many of the worms were not killed by the spray applications and succeeding generations increased steadily in abundance and destructiveness.

The substitution of dusting for spraying was advised and many planters were shown how to make the improved form of "pole and bag outfit" which has come to be used here. The saving in labor of application and the increase in the degree of control obtained were very striking in favor of the dust. Climatic conditions are ideal for such work as there is no rain to wash the poison from the plants. In some cases our type of cotton dusting saddle guns were used but they preferred to strap these over the shoulders of an Indian who walked through the rows rather than to drive a horse through and break many branches of the cotton. The entire situation in Peru indicated the advisability of providing for airplane dusting service for leaf worm control which has proven sosatis factory here in the United States. Accordingly, at the request of leading cotton planters and with the official approval of the Peruvian Government, arrangements were made with the Huff Daland Dusters, Inc., of Louisiana to establish a similar service for Peruvian planters. In December, 1926, a staff of seven men with three dusting planes sailed for Peru and are now initiating there this advanced type of leaf worm control work. It is reasonable to suppose that the widespread, repeated and uniform applications of calcium arsenate distributed from airplanes will accomplish a far more satisfactory and profitable control of leaf worms in Peru than has heretofore been possible. This work may also serve to control in considerable measure some of the other important cotton pests beside the leaf worms.

The Peruvian Cotton Square Weevil
(*Anthonomus vestitus* Boh.)

This weevil was described in 1859 but nothing was known of its host relationships and economic importance until 1910 when Dr. C. H. T. Townsend working in northern Peru found that the species was breeding in cotton squares. This discovery was made at about 2° south latitude and not far from the small island off the coast of Equador where the first specimens were taken. The writer was working some six hundred (600) miles further south and found these weevils common in practically every field examined and ranging from sea level to an elevation of about two thousand (2,000) feet. Dr. Townsend expressed the conviction that the species would be found in all cotton-growing sections of Peru but stated that he had not found the species in Brazilian cotton fields. There is no positive record of its occurrence outside of Equador and Peru. The economic importance of the species within this area has not been fully determined, but it certainly does not equal the Mexican cotton boll weevil in destructiveness.

The Peruvian cotton square weevil resembles the Mexican cotton boll weevil in general shape but is very much smaller in size. Adults range from about 2.5 to 4 mm. in length. They are of a light brown or tan color where the scale covering has not been removed. The description "pisceous" as given by Pierce appears to be misleading altho the integument is brown in color. The adults are very inconspicuous in appearance, shy and very active. They run, take flight or drop much more readily than does our boll weevil and, therefore, adults are rarely seen in the field. The species breeds almost exclusively in squares that are less than one-half inch in diameter. Only the very small bolls are ever attacked. Evidently larger squares and even half-grown bolls cannot be penetrated for successful oviposition. The place of oviposition on squares is usually in the constricted basal portion so that the egg is placed in the base of a petal rather than among the pollen sacs. At that point proliferation forms more readily and produces a characteristic bulge just above the egg puncture but the "wart" that marks boll weevil punctures is not formed. The infested squares fall to the ground more quickly after oviposition than do those attacked by the boll weevil. The developing larvae and pupae appear to be more resistant than the boll weevil to heat and drought. Practically no dead weevils were found in fallen squares even where the ground was very dry and exposed to the sunshine.

The presence of the Peruvian cotton square weevil is indicated first, and always most plainly, by the flaring of squares. In one case, twenty-

five punctured squares were found on a single plant and appeared to be the work of a single female. Usually, however, not more than six or eight punctured squares are found on a plant. As a general thing it does not seem likely that this species, although serious, will ever do more than one-half as much damage to cotton as does the boll weevil. It appears that the species is probably strictly tropical but we have no evidence at the present time to indicate whether it can or cannot survive freezing temperature during its hibernation period.

Boll-Boring Lepidopterons

While no pink boll worm specimens were found and we believe that none yet occur in Peru, we did find some four different species of small size Lepidopterous larvae boring into cotton bolls. Among these and occurring particularly in the decaying corollas of unshed blooms and in decaying bolls also, was a species which appeared to be our common *Pyroderces rileyi* Wals., known to us commonly as the pink corn worm or false pink boll worm. In a majority of cases this species appeared to be feeding as a scavenger but it was quite evident that its activity served to increase the proportion of old corollas which remained attached to the tips of the bolls. After working in such corollas it seemed that the larvae sometimes also bored directly in the sound boll tissue beneath the corolla, thus causing a direct primary injury to the growing boll. This matter calls for additional investigation as there is a possibility of two species which are very close in their resemblance having been confused in these hurried observations.

Two or three other small Lepidoperous larvae (species undertermined) were found commonly boring into bolls. These larvae were from one-half to five-eights inch long when full-grown. Unfortunately there was not sufficient time available for breeding out these species. Still another species resembling rather closely our cotton boll worm in size and in its feeding work was found only rarely.

The work of these caterpillars was frequently followed by the development of fungus diseases or boll rots of different types which often cause complete destruction of the boll. One larva appeared to enter the boll by preference at the very tip and its entrance was followed by a cracking open of the immature boll with complete loss. In some fields the owners felt that the crop was almost a complete failure because of the work of these larvae. A rather close examination, however, indicated that not more than 20% to 25% of the total crop was being destroyed by this agency. Some of these larvae attack squares as well as bolls.

Cotton Plant Lice

While no case of extreme damage by a plant louse species was observed directly, reports from numerous planters indicated that earlier in the season, at about the time that squares began to form, heavy infestation with some plant louse species was common. This attack dwarfs the plants and is likely to interfere with the stand. Apparently sooty mold (referred to by the Spanish as the "black melasa") forms abundantly and adds to the damage done directly by the feeding of the lice. Up to this time there has been no attempt to control these plant lice. It is probable that some effort will be made in the near future to control this pest by applying nicotine sulphate and hydrated lime dust.

AN INTERESTING APHID OF THE PECAN

By Theo. L. Bissell, *Assistant Entomologist, U. S. Department of Agriculture*

Abstract

An aphid, *Myzocallis fumipennellus* F., injures pecan foliage in several sections of the pecan belt, including southern Georgia. The species is marked by its dark color, prominent tubercles and the effect of its feeding on the leaves. Around the puncture of a nymph appears a yellow spot which turns brown. Spots are identified by a rectangular effect and a dark margin. Heavy infestation may cause defoliation.

Of several aphids known to live on the pecan, one species, *Myzocallis fumipennellus* Fitch, may be considered of economic importance. During 1926 and 1927 considerable injury caused by this insect has been observed in orchards of southern Georgia. It is known to be of more or less importance in several sections of the pecan belt from Texas to North Carolina. Only once[1] has the species been mentioned in economic literature.

Published accounts give as the range of this aphid New York,[2] Illinois and Missouri[3] and North Carolina,[1] to which the author adds the District of Columbia,[4] Georgia, Florida, Louisiana and Texas. Fitch[2] and Davis[3] record it on hickory. Budded pecans are preferred in southern Georgia, although seedlings and at least two other species of *Hicoria* act

[1]Leiby, R. W. 1925. Insect Enemies of the Pecan in North Carolina, N. C. Dept. Agr. Bul., Feb., 1925, pp. 67. (p. 37).

[2]Fitch, Asa. 1855. (First) Report on the Noxious, Beneficial, and Other Insects of the State of New York, Albany, pp. 176. (p. 166).

[3]Davis, J. J. 1910. Two Curious Species of Aphididae from Illinois, Ent. News, Vol. 21, pp. 195-200, pl. VIII. (p. 198, *Callipterus caryaefoliae* n. sp., Synonym).

[4]Pergande, Theo. Unpublished record. From material in the U. S. Nat. Museum collected by Pergande in 1897 and 1908.

as hosts. Of cultivated pecans in Georgia and Florida, the Stuart and Schley are attacked more than some other varieties.

Myzocallis fumipennellus F. is a rather short, robust aphid, the largest individuals measuring approximately 1½ mm. by 1 mm., and is of striking appearance. The body color is pale brown or olive green, but dark brown tubercles and other heavily chitinized parts give an impression of black. Wax secreted from several points on the dorsum makes a regular pattern of white dots (not apparent in specimens mounted in balsam). The wings are clear with brown veins. Fourteen pairs of tubercles varying greatly in size give the back and sides an uneven surface. The outstanding feature of this insect is its dark color, and accordingly it might be called the "Black pecan aphid."

As to its habits, the aphid is found on the lower surfaces of leaves, occasionally on the upper surfaces and rarely on the nuts. Hardened leaves are preferred for feeding to those newly opened. It has been noted that trees beside a building are apt to be more heavily infested than those growing at a distance. The adults are fairly active and leap when disturbed.

An especially interesting characteristic of this *Myzocallis* is the peculiar effect of its feeding on the leaves. Two to four days (in July) after a nymph commences feeding a pale yellow area develops around the puncture. The area enlarges and becomes more intense in color until in four to seven days after the first feeding it is bright yellow shading into the leaf green on the edge and covers approximately 0.5 sq. cm. of surface. (See Pl. 14, fig. 1.) The effect spreads irregularly in all directions from the puncture and goes through the leaf tissue so that its extent is the same on both sides. The color is more intense on the upper surface, whether the aphid feeds from above or from below, because the upper surface is smoother than the lower. The discolored area is limited in part by primary veins which make it roughly rectangular. About the time an injured portion ceases to enlarge it gradually turns brown, starting at the feeding puncture. The margin usually becomes dark brown to black. All of the injury does not change, as an indefinite yellow border remains against the green. The brown area shrinks or warps and causes the leaf to curl. The square effect and the dark margin help to distinguish the injury from brown spots due to other causes.

If the infestation is severe, defoliation may result. When aphids become quite numerous the yellow and dead areas merge and the leaflets wither and fall prematurely. Often a leaflet drops while a portion is still green. Rarely all of a compound leaf falls, first the leaflets and then the petiole.

1.— Effect of *Myzocallis fumipennellus* F. on pecan; (slightly reduced). 2.— Injured areas on leaflets, upper leaflet curling, lower leaflet with less advanced injury; Defoliation caused by aphids on a caged leaf.

Figure 2, plate 14, shows a part of a pecan leaf on which was caged a colony of *Myzocallis* on August 28. On September 17 the cage was removed and the leaf photographed. The leaflets (five) which are shown in their respective positions by the petiole were affected as follows: Three had withered and dropped; one partly green had dropped; one partly green was still attached. Aphids can be seen on the two last. No record was made of the number of aphids in the cage but by examining the photograph the number of individuals present is estimated to be 500. A similar effect was produced in three other cages run at the same time under like conditions while the leaflets in a fifth cage run without aphids (check) were unchanged at the close of the experiment.

It is difficult to evaluate the damage caused by the black pecan aphid because the nut is not directly injured. It is possible that there is a check on tree growth by the reduction of active leaf surface which would have an indirect influence on nut production.

From the author's observations this insect does not become abundant until midsummer. One isolated tree was found to be noticeably infested about the middle of June, 1926, but no general infestation was seen in orchards till the last of July. By late August, 1925, trees in some sections were quite brown and leaves were falling, defoliation becoming marked in the month of September. In the year 1926 there was less defoliation, which might be explained by the pronounced difference in weather conditions. The temperature for 1925 was far above the average and precipitation was somewhat low, while in 1926 temperatures were a little below normal and rainfall was well above.

THE RELATION OF LEAF COLOR AND LEAF SIZE TO BOLL WEEVIL INFESTATION[1]

By DWIGHT ISELY, *Department of Entomology, University of Arkansas.*

ABSTRACT

Field experiments in 1925 and 1926 indicate that the boll weevil has a marked preference for cotton plants with green foliage to those with red foliage.

The boll weevil apparently has little choice between small leafed and large leafed varieties, provided the size and vigor of the plants is about the same.

The relation of two leaf characters, color and size of the leaf surface, to abundance of the cotton boll weevil was studied in a series of experiments carried on at the Arkansas Experiment Station farm at Fayetteville, in 1925 and 1926. The relation of other vegetative factors to the

[1]Reseach Paper No. 95, Journal Series, University of Arkansas.

degree of boll weevil infestation has received considerable attention previously from other investigators, particularly from Cook[2]. It is well established that a heavy foliage is favorable to the weevil. On this basis, it is assumed by many cotton growers and some cotton breeders that plants with relatively small or deeply cut leaves are less susceptible to boll weevil injury than plants with large leaves. Accordingly, this leaf character is regarded by some plant breeders as a desirable one to develop. However, as far as I know, this has never been given experimental trial previously. Color characters also have apparently received little serious attention.

These studies of the relation of leaf characters of cotton to the boll weevil were undertaken incidentally, along with studies of dispersion in an isolated cotton field on the Experiment Station farm. Fayetteville is on the northern slope of the Ozarks and is about forty miles north of what is usually considered the northern limits of the cotton belt. However, there is a small acreage of cotton grown in the Fayetteville vicinity, and since 1921 the boll weevil has been established in this territory. No other cotton was grown near the field in question, however, and consequently it was unaffected by weevils migrating in from other fields, until near the end of the season.

The results obtained are not significant from the economic point of view, but may be of interest to other entomologists, and may have some bearing on future experimental work. It may be stated at the outset that the results with both leaf characters in question were the opposite from that which had been expected.

The choice of varieties used in these experiments was based quite largely upon the recommendations of J. O. Ware, Cotton Specialist in the Agronomy Department. For contrasting leaf color, one variety used was Winesap, which has a dark wine red colored foliage. While the character of the lint and bolls has little to recommend it, the variety is fairly early and sets fruit rapidly. It is used in breeding experiments, but is not grown commercially, to any extent at least, in Arkansas. As a green leafed variety, one of the early northern grown strains of Acala was chosen, which was similar to Winesap in earliness and in rate of fruiting.

For comparison of leaf size, one series was of Okra Leafed Acala, a variety with deeply incised leaves resembling those of okra rather than

[2]Cook, O. F. *1906*. Weevil-resisting adaptations of the cotton plant. U. S. D. A. Bur. Plant Indus. Bul. 88. 87 p. 10 pl.; *1911*. Relation of drought to weevil resistance in cotton. U. S. D. A. Bur. Plant Indus. Bul. 220. 30 p.; *1923*. Boll-weevil cotton in Texas. U. S. D. A. Bul. 1153, 20. p. Illus.

cotton, contrasted with a strain of Lone Star from Texas with very large, broad leaves. The Okra Leafed Acala is not grown commercially in Arkansas. These two varieties were both relatively late. Another series contrasting two medium early varieties was used. As representative of the small leafed type, a strain of Lone Star from Northeastern Arkansas with foliage slightly larger than, but similar in form, to that of Trice, Express or Delfos was used. Mexican Big Boll, one of the largest leafed medium early fruiting varieties, was used for contrast. These two varieties do not represent as great a contrast in size of foliage as the Okra Leafed Acala—Lone Star (Texas) series, but the difference is about as great as could be secured by using commercial varieties with similar fruiting habits.

In 1925 these varieties were planted in series of six alternating plots, with rows 50 feet long. The series in which leaf size was contrasted were 20 rows wide. The plots in the color contrast series, from which little was expected, were only 10 rows wide. The arrangement of plots is shown in Table 1. In 1926 a somewhat different arrangement was used. In the Winesap-Acala combination, the varieties were planted in alternating plots in two adjacent series, of four plots each. However, in one series the odd numbered plots were Winesap, while in the other they were Acala, giving the plot arrangement a checkerboard effect. The Lone Star (Texas)—Okra Leafed Acala combination was also planted in two series similarly arranged. In view of the results of 1925, the Mexican Big Boll—Lone Star (Arkansas) combination was discarded. All rows were 50 feet long and all plots were 16 rows wide. The arrangement of the Winesap-Acala combination and one adjacent Lone Star (Texas)—Okra Leafed series is shown in Table 2.

In 1925 the cotton was planted on May 17 and 18, and all of the earlier varieties had begun setting squares by June 30. In 1926 cotton was planted May 16 and 17. On account of dry weather, germination was slower and setting of squares did not begin until about July 10. Weevils were not released in these plots until fruiting was well under way.

Red Leafed Versus Green Leafed Cotton

An apparent preference by the boll weevil for cotton plants with green foliage over those with red foliage was first noted by the writer in August of 1923, in a variety test carried on by the Agronomy Department on the branch experiment station farm at Scotts. The rows of Winesap cotton were in all cases distinctly less heavily infested than the adjacent rows of cotton with green foliage. A few weeks later after the late summer dis-

persion of weevils had taken place, all cotton red or green had about the same degree of infestation. Little significance was attached to the observation at the time.

The experiment in 1925 was confined to a series of three small plots of Winesap cotton alternating with three similar plots of Acala. Parallel with these plots on one side was a series of plots of green leafed cotton with about the same fruiting season. These varieties, Lone Star (Arkansas) and Mexican Big Boll, while intended for the leaf size experiment, were also used for comparison with the Winesap plots.

A total of sixty newly transformed weevils were released at a middle point in each of the Winesap and Acala plots. The first release was made on July 18 and the last was made on July 25. On each day when an infestation was released the same number of weevils were placed in each plot. By August 3, the infestation had spread practically over all six of these plots, and also into the adjacent series of green leafed cotton plots beside them.

Counts of the percentage of infested squares in each plot of the two series were made on August 14, 21, and 28. All counts of infestation were based on 200 squares taken in each plot. These percentages are shown in Table 1. In this table the Mexican Big Boll—Lone Star (Arkansas) series is designated as series F and the Winesap—Acala series is designated as series G. In series G, plots 2, 4, and 6 were red leafed cotton. It will be noted that while there was great variation in degree of infestation on the varieties with green foliage, yet on August 14 and 21 the plots of Winesap were in all cases less heavily infested than the adjacent plots. By August 28, as the infestation approached total, this difference began to decrease. The next week uninfested squares were rare on any variety and no counts were made.

TABLE 1. PERCENTAGE OF SQUARES INFESTED BY BOLL WEEVIL ON PLOTS OF RED-LEAFED COTTON, CONTRASTED WITH ADJACENT PLOTS OF GREEN-LEAFED VARIETIES, FAYETTEVILLE, ARKANSAS, 1925

Date	Series	Plot Number					
		1	2	3	4	5	6
August 14	F	25	46	15	16	12	38
	G	22	W 7	12	W 1	16	W10
August 21	F	69	78	56	63	56	64
	G	80	W33	63	W16	60	W26
August 28	F	77	77	79	66	66	59
	G	79	W50	63	W71	77	W44

W = Cotton with wine red foliage.

The arrangement of plots in the second season's comparison between red and green cotton made in 1926, is shown in Table 2. In this table is also shown the position of the adjacent plots of a solid green leafed series of Lone Star (Texas) and Okra Leafed Acala.

TABLE 2. ARRANGEMENT OF PLOTS IN TEST FOR COMPARISON OF RELATIVE ATTRACTIVENESS OF RED-LEAFED AND GREEN-LEAFED COTTON TO BOLL WEEVIL, FAYETTEVILLE, ARKANSAS, 1926

Series	Plot Numbers 1	2	3	4
D	Lone Star	Okra Leaf	Lone Star	Okra Leaf
E	Winesap	Acala	Winesap	Acala
F	Acala	Winesap	Acala	Winesap

Fifty newly transformed weevils were released on each of these plots between August 5 and 8. By August 17 they were fairly well spread over the plots and the first infestation counts were made. Subsequent counts were made on August 24 and 31. These percentages are shown in Table 3. In making infestation counts, 25 squares were taken from alternate rows of each plot, making a total of 200 to the plot. It will be noted that in spite of the variation in the degree of infestation in each of these plots, without exception the plots of Winesap were less heavily infested than the adjacent green leafed plots. The average infestation of the eight green leafed plots on August 17 was 43.87%; on August 24, 53.94%; on August 31, 58.62%. The average infestation on the four red leafed plots was on August 17, 14.25%; on August 24, 16.12%; and on August 31, 32.25%.

TABLE 3. PERCENTAGE OF SQUARES INFESTED BY THE BOLL WEEVIL ON PLOTS OF RED-LEAFED COTTON CONTRASTED WITH ADJACENT PLOTS OF GREEN-LEAFED VARIETIES, FAYETTEVILLE, ARKANSAS, 1926

Date of Infestation Counts	Series	Plot Numbers 1	2	3	4
August 17	D	41	49	46	16
	E	W15	79	W 8	54
	F	34	W24	32	W14
August 24	D	74	64	64	30
	E	W42	60	W18.5	41.5
	F	60	W31	35	W 5
August 31	D	80	71	60	42
	E	W50	58	W26	58
	F	53	W18	47	W35

W = Cotton with wine red foliage.

No explanation for the apparent preference for green leafed to red leafed cotton is offered, beyond a series of observations on the boll weevil's sense of color, by C. R. Jones in 1907, reported by Hunter and Pierce.[1] In this series of observations, weevils were given opportunity to enter tubes of different colors from a general box, and among the colors tested were green and red. Green was found to be more attractive than red at the rate of 6.0 to 3.8.

No economic importance can be attached at present to the apparent degree of immunity of red leafed cotton, since there is no red leafed variety which agronomists recommend for commercial planting. It is also possible, judging from the relatively even distribution of the weevil at the end of the season, over red and green plants alike, that this apparent immunity might disappear if the weevil had only red cotton for food.

Small Leafed Versus Large Leafed Plants

Between small leafed and large leafed varieties, the boll weevil apparently has little choice, judging from experiments in 1925 and 1926, at least if the size of the plants is about the same. Since the results of this experiment are largely negative, only a summary of results will be given. In 1925 only one infestation count was taken in the Okra Leaf—Lone Star (Texas) series. This count was made August 17, 20 days after the first release of weevils in these plots. Curiously enough, the Okra Leafed variety was more heavily infested than the broad leafed variety, the ratio being 33.50 for Okra Leaf to 22.50 for Lone Star. This was accounted for because the plants on one of the Okra Leafed plots were unusually luxuriant, due to more fertile soil, and on account of this inequality no more counts were made.

The infestation counts of the Mexican Big Boll—Lone Star (Arkansas) series have already been given in detail in Table 3. These counts showed the relatively small leafed Burdette Lone Star slightly more heavily infested on two dates than the broad leafed Mexican Big Boll. The summaries of infestation are: August 14—Lone Star (Arkansas), 33.33%; Mexican Big Boll, 20.33%. August 21—Lone Star (Arkansas), 68.33%; Mexican Big Boll, 60.33%; August 28—Lone Star (Arkansas), 66.67%; Mexican Big Boll, 71.33%.

In 1926, the broad leafed Lone Star (Texas) was slightly more heavily infested than the Okra Leafed Acala. The summaries of infestations are: August 17—Lone Star (Texas), 32.75%; Okra Leaf,

[1]Hunter, W. D. and Pierce, W. D.—The Mexican cotton boll weevil. U. S. D. A. Bur. Ent. Bul. 114, p. 43. 1912.

29.75%. August 24—Lone Star (Texas), 57.75%; Okra Leaf, 41.12%. August 31—Lone Star (Texas), 70.00%; Okra Leaf, 66.00%.

The chief value of these negative results is that they differ from the popular belief and may eliminate one character which some plant breeders have considered. The elimination of this character may also be of value in future experimental work with boll weevil control.

IS THERE ANY DEFINITE BASIS FOR FORECASTING INSECT OUTBREAKS AND ASCERTAINING IF CONTROL MEASURES ARE PRACTICABLE?

A DISCUSSION FROM A RESEARCH STANDPOINT

By W. E. HINDS, Ph.D., *Entomologist, Louisiana Experiment Station and Extension Service*

The subject presented for discussion is certainly one of the most difficult, but at the same time, most practically important phases in many important insect control problems. Every such biological problem is exceedingly complex, and the important factors affecting it cannot be predicted with certainty. A careful investigation of the life history of any insect is likely to reveal the fact that different species respond in a different way to the same set of environmental conditions. The nature of this response must, therefore, be determined by a very careful and prolonged study of each important species.

Extended studies of particular species have been made with a number of our most important economic species, and where such is the case it is likely that the investigators concerned develop a fairly clear idea of the most evident important factors from a study of which they find that they are able to anticipate to some degree at least the prospective abundance of the species at the beginning of its development during the following season. Thereafter it will probably be true that the influence of climatic conditions which cannot be predicted through any long period of time are so important in their effect upon the multiplication or distribution of the species that the final abundance and extent of damage to any particular crop cannot be forecasted with any degree of accuracy at the beginning of the growing season. The rapid development of parasites or predators, or a very abrupt change in temperature conditions, or the occurrence of certain types of rainfall may change "prospects."

Perhaps the Extension workers in Entomology may appreciate the complexity of this problem if we merely enumerate some of the factors

which are likely to be of importance in any such effort at "forecasting." The factors mentioned happen to be, in the main, some which have been found important with regard to the Mexican cotton boll weevil with which the speaker has had rather extended experience.

It is important to know first of all, something as to the fall population of the species that is likely to enter hibernation. This study will involve records as to comparative abundance during a series of seasons. The abundance and favorable condition of the preferred fall food supply particularly is likely to be an important factor. The occurrence of early or late killing frosts in the fall affects the feeding, late fall multiplication of the species, the length of the hibernation period, etc. With the boll weevil the occurrence of still another cotton pest (the cotton leaf worm) which does not attack the boll weevil directly may have an all important influence upon this fall development of the species and the number of individuals, or the fall population, which may enter hibernation. The boll weevil has no other food plant than cotton, neither does the cotton leaf worm. When the leaf worm strips the cotton of its foliage, it causes the immediate cessation of growth and the shedding of all squares and small bolls which may be present on the stalks. In this way the leaf worm serves to check immediately and to a very important degree, the late fall multiplication of the boll weevil and often destroys its food supply so completely as to cause practically a wholesale destruction of the weevils before it is possible for them to hibernate successfully.

With many species, particularly Lepidoptera, the condition of parasitism in the fall may be of great importance and must be determined.

During the hibernation period of the species a group of factors that are important would include particularly, the abundance and accessibility of favorable hibernation shelter, the liability to destruction during its hibernation period by predators, etc. The amount and distribution of winter rainfall is likely to be important. Overflows, standing water, or even the movement of water may affect the survival of the species or its important natural enemies and may change the area of distribution to an important degree. For example, there seems now to be grave danger that through the occurrence of heavy winter rains in the infested area, corn stalks carrying hibernating European corn borer larvae may be washed into streams and drift long distances, distributing the species in this way. One of the most important winter factors is, of course, minimum temperature and if this falls unusually low or repeatedly reaches a point below the critical point for the insects, the percentage surviving the winter is likely to be very greatly reduced. Again, wide fluctuations in winter temperatures may be important as high

temperature continuing for a considerable time may bring about a degree of activity on the part of the insect which will shorten its life or decrease its power of resistance through the balance of its hibernation.

In the spring group of factors, one of the first to be considered is the earliness of the season. This shortens the hibernation period and favors the development of the necessary food supply. In forecasting the early spring activity of a species, it is often possible to correlate the initial appearance or the beginning of breeding with some very plain common natural phenomenon such as the blooming or leafing of some particular kind of tree or plant. It is certainly much more difficult to estimate the factor of spring food supply when a species has a number of equally favorable host plants and if the species feeds upon a number of wild host plants.

With some species it is quite certain that hibernation cage experiments furnish a fairly good index as to the average percentage of survival under natural field conditions. This seems to be particularly true with the boll weevil and a great deal of such work has been done in connection with that species. Where the records are kept for a number of years an average, or normal, percentage of hibernation is ascertained and any unusual variation from this is noticeable. It has been found quite possible with the boll weevil to determine rather accurately the condition of initial infestation that may be expected, but it is not possible to go beyond this and forecast the development during the summer period which is ultimately the most important factor so far as damage by the pest is concerned.

In the summer group of factors, maximum temperatures are likely to be fully as important as winter minimum temperatures are. High heat, especially when continuing for prolonged periods, is almost invariably coincident with a period of unusual deficiency in rainful and the combination of heat and drought is a difficult one for many insects to endure. This is true particularly with the boll weevil during the first six weeks after squaring becomes common, as fully half of the development of the insect takes place after the square has fallen to the ground. If then the plants are not large enough to shade the major part of the ground area a majority of the insects are likely to be exposed to the direct sunshine and under conditions making it possible for the temperature at the surface of the ground to rise above 118 degrees F. which is approximately the critical maximum for this species. The Mexican bean beetle (*Epilachna corrupta*) is also subject to wholesale mortality of larvae and pupae during periods of extreme heat. With many other species, on the contrary, such a combination of conditions

is not of critical significance. The insect may be able to move away from unfavorable conditions to those which it can endure, or the species may feed in the shade and well above the surface of the ground where the maximum temperature experienced is not nearly so high as at the surface of the ground in sunshine. Therefore, these factors must be studied for each particular species and may or may not be found to be of significance.

Summer rainfall may be important both in total amount and in the character of the rain. That is, it may make a vast amount of difference whether one inch of rainfall comes in a slow drizzle with little "drive" to it or whether the same amount of rain falls in large drops and driven by a heavy wind so that they strike with sufficient force to beat the foliage and to wash insects to the ground. Naturally a factor of this kind cannot be forecasted, but may be of extreme importance with such insects as plant lice.

Another summer factor is found in the number of generations produced by any species and in the rate of multiplication. These factors may be known with a high degree of accuracy based upon the average of observations on a large number of individuals. In this connection, normal or average mortality entirely apart from any artificial control effects must be considered. Theoretical multiplication possibilities are rarely borne out in actual experience. If this were not true, mankind would probably not be in existence on the earth today.

Many other considerations might be mentioned as bearing upon this problem of forecasting insect outbreaks, but probably enough has been said to indicate that there are great difficulties in the way of this ever becoming applicable to all economic species. Some may be susceptible to a fairly accurate forecasting and the experience of years may bear out such forecasts in a practical way. Other species, however, may present difficulties which cannot be overcome and the uncontrollable and unknowable factors may predominate so as to make forecasting an impossibility. This will probably be found true with a great many of the species which are rather sporadic in their occurrence and particularly those which are dependent upon migration through long distances during successive generations. In many cases, it is quite certain that the adults of winged species are carried for long distances by high air currents and the direction of their movement and the distance that they go cannot be foretold.

Undoubtedly there are many phases of insect multiplication studies to which the "Theory of Probability" may be applied and no doubt this will be done increasingly in the near future, but at the present time we

do not see how this can be applied in a practical way to certain other phases of insect activity. Meantime the empirical test of practical experience may be our best guide and may prove to be of real service in many cases in meeting the problems of insect control most successfully.

REGIONAL COOPERATION IN EXTENSION ENTOMOLOGY

By ERNEST N. CORY, *State Entomologist College Park, Md.*

In every state there are certain problems in insect control that are identical with those in the adjacent states in many particulars. Of course, topographical and meteorological conditions vary and thereby modify the intensity of the infestations. Likewise, economic and sociological conditions determine the importance of many problems, but in the main, the problems of one state are usually the same for nearby states except in the isolated cases of infestation by imported pests.

It follows, therefore, that the method of attack in one state will be of the utmost interest to the workers in adjacent fields. No state has such a large force of entomologists engaged in research that it can supply all the ammunition that the extension worker requires. He must look to investigators in other states and Federal entomologists for much of the information he is expected to disseminate. Don't forget that the extension worker is supposed to be omniscient, omnipotent and omnipresent. In order to approximate the first attribute he must rely upon brief and inadequate contacts with his own experiment station workers, the annual meetings and a hurriedly gathered mass of new bulletins, thrust into his grip on his sporadic return to headquarters, to be read on a lurching bus or "rattler" as he goes from place to place in an attempt to be omnipresent. By the time he gets back to his office, a new crop of bulletins is at hand, some of which may upset the conclusions he has reached from his previous reading. No worker in the entomological field is so handicapped in subject matter as the extension entomologist, unless he confines his efforts to a limited field and then he lays himself open to the criticism that he is neglecting other crops or interests. Few states have the organization to serve every interest by specialists.

A partial remedy for these ills lies in regional cooperation in research and extension programs. The difficulties that beset cooperation in research are not insurmountable, if a broad concept of cooperation is kept in mind and an unselfish attitude towards one's co-workers is maintained.

It is perfectly possible and proper for investigators, in regions of similar conditions, working on the same problem of major interest to

each state, to meet at frequent intervals for the purpose of familiarizing each other with the progress made, the difficulties encountered and the leads established or indicated. Such conferences tend to increase mutual respect, establish confidence and promote the work. This is not theory but is fact. It has been proved to the writer's satisfaction by the several conferences on the Cumberland-Shenandoah Region apple production problems, from which issued the joint spray program and the rosy aphis project; by the oriental fruit moth conference at Harrisburg, in 1926; by the potato tuber moth conferences in Virginia; by the many Japanese beetle and corn borer conferences and by others too numerous to mention. Conferences on research problems should be attended by extension workers whenever possible, as they would serve as his clearing house.

The foregoing relates to subject matter almost entirely. What of methods and administration? What sells any article of daily use? National advertising. The extension entomologist has something infinitely harder to sell and yet he sticks to local advertising. National advertising or, in other words, universal methods, are not possible maybe but the same methods used over a region of similar characteristics with essentially the same insect problem would most certainly have a greater chance of selling the idea than the efforts of an individual, uncoordinated with the other workers in adjacent states.

Regional cooperation, in its broadest sense, in research projects is an accomplished fact as evidenced by the attitude of the Federal Bureau of Entomology, and the more recent state activities. Regional cooperation in coordination of subject matter and methods has made a beginning, yet much more can be accomplished by whole-hearted cooperation in regions of similar problems. Insects disregard state lines. Why should we consider state lines in formulating our plans of attack? Is there any good reason why eleven states should each have different recommendations for the control of the Mexican bean beetle, when one plan, arranged in conference, would meet the situation and vastly increase the respect of the farming element, many of whom, especially those along the borders, get the publications of several states.

We stand at the threshold of a broader, more efficient extension program if we adopt generally the regional concept of cooperative endeavors and build up as rapidly as possible a body of recommendations that are identical, for regions where insect activities are comparable.

SOME RESULTS WITH BAIT PANS AGAINST THE ORIENTAL MOTH, *L. MOLESTA*, BUSCK

By J. R. STEAR, *Pennsylvania Bureau of Plant Industry, Chambersburg, Pa.*

ABSTRACT

Bait pan experiments over a two year period failed to give appreciable control. Tests with various methods of placing bait pans showed that while a pan in every tree gave the highest catch, a pan in every second tree caught almost as many.

Variation in the intervals of cleaning and adding molasses to the bait pans showed that a daily removal of insects and frequent additions of molasses resulted in the highest catch of adults.

Releases of marked adults in the bait pan plot showed a small percentage of recovery in the pans, the highest being 30% caught over a period of nine days after release.

From the data on control and the small percentage of released adults recovered it is concluded that bait pans offer little hope in practical control.

During 1926 and 1927 at Chambersburg, Pa., the writer tested out on a small scale, the effectiveness of bait pans in controlling the Oriental moth. The results obtained and some observations made in this connection are presented in this paper.

In 1926, three plots of Elberta peach trees were hung with bait pans as follows: Plot 1, a pan in every fourth tree; Plot 2, a pan in every tree; Plot 3, a pan in every other tree. (See below for plan of the plots.) Except that Plot 1 was interplanted with apples similar conditions prevailed for all three plots. Plot 1 contained 110 trees, 85 of which were peach, Plot 2 contained 99 trees and Plot 3, 98 trees all of which were peach. The plots were separated by five rows of check trees.

The containers used were half-gallon enameled stew pans. The bait used was stock molasses at the rate of one part to ten of water. The pans were examined daily except Sunday and all captured insects removed with a sieve. A tablespoonful of molasses was added twice a week to maintain the level of attractiveness and water added when necessary to keep fairly full.

Records were kept of the total catch in each plot for the season. Although the catches were rather light due largely to a total crop failure in 1925 and a small overwintering generation, the numbers taken in the different plots are of interest. See Table 1.

TABLE 1. L. MOLESTA ADULTS TAKEN IN BAIT PAN PLOTS

Plot No.	Bait pan arrangement	No. of pans	No. of trees	Total catch	Average per pan
1	A pan in every 4th tree	30	84	1024	34.1
2	A pan in every tree	99	99	1444	14.6
3	A pan in every 2nd tree	50	98	1386	27.7

PLAN OF BAIT PAN PLOTS IN 1926

Plot 1

o A e A o A e A o A e
e X o o o e o o o e o
o A e A o A e A o A e
e o o o e o o o e o o
o A e A o A e A o A e
e o o o e o o o e o o
o A e A o A e A o A e
e o o o e o o o e o o
o A e A o A e A o A e
e o o o e o o o e o o

Plot 2

o o o o o o o o e e e e X e e e e

The catch per plot varied with the number of pans. Plot No. 2 with a pan in every tree caught the greatest number and Plot No. 1 with a pan in every 4th tree caught the least. The catch per pan increased as the number of pans decreased but not in inverse ratio. Making corrections for the unequal number of trees in each plot and assuming the catch in plot No. 2 with a pan in every tree to be 100%, that of Plot No. 3 with a pan in every 2nd tree was 97% and that of Plot No. 1 with a pan in every 4th tree was 84%. The difference between the catch of Plot 2 and 3 was so small it does not appear to be any advantage to use more than a pan to every two trees. The difference in favor of a pan to every other tree over a pan to every 4th tree seems sufficient to justify using a pan to every other tree.

The infestation was very low in the Elberta block in 1926 and no difference in control was noted between the bait pan plots and the remainder of the block. Eight trees at the center of each plot and four check trees, 5 to 10 rows from the plots were used as count trees. The results are given in Table 2.

TABLE 2. ELBERTA COUNTS, BAIT PAN EXPERIMENT, 1926

Plot No.	Bait pan arrangement	Total fruit	No. wormy	% wormy
1	A pan in every 4th tree	5100	47	.9
2	A pan in every tree	5199	20	.38
3	A pan in every 2nd tree	5151	81	1.57
Checks	No pans	840	10	1.19

Although the Elbertas showed an average of less than 1% wormy fruit when harvested September 3rd, a nearby block of Salways picked on October 4th were 30% wormy. For further work with bait pans in 1927 it was decided to use the Salway block. A plot, 19 rows square was hung with bait pans in every other tree. Pans were hung in the orchard April 22nd and maintained until harvest. Refiner's syrup 1 to 10 was used in place of stock molasses. Otherwise the pans were cared for as in 1926 except for certain rows where the treatment was varied as noted later. Due to apple interplants and missing peach trees, the plot contained but 232 peach trees in which 156 pans were hung. A record of the total catch from the plot was not taken. The catches in the pans of two rows, G and K (see plan below) were recorded. These two rows with a total of 17 pans caught 2080 moths or an average of 122.2 moths per pan. Considering this catch to be average for the plot, about 19,000 adults were taken in the 156 pans.

A check up at harvest time on Sept. 29th failed to show any definite difference in favor of the bait pan plot over the check trees. Seven bait

pan trees, six of which were in one row across the plot and five check trees were used as counts. Examination was external only except in the case of bait pan tree No. 4. The results are given in Table 3.

TABLE 3. SALWAY COUNTS, BAIT PAN EXPERIMENT, 1927

Bait pan plot	Total fruit	Apparently Wormy No.	Apparently Wormy %	Actually Wormy No.	Actually Wormy %
Tree 1	410	131	31.9		
" 2	608	181	29.7		
" 3	287	96	33.4		
" 4	206	52	25.2	118	57.2
" 5	273	77	28.2		
" 6	111	38	34.2		
" 7	198	52	26.2		
Checks					
Tree 1	167	83	49.7		
" 2	84	36	42.8		
" 3	182	56	30.7		
" 4	230	43	18.7		
" 5	113	11	9.7		

Average of bait pan plot—29.9% apparently wormy
" " checks —29.5% " "

A study of the table shows considerable variation in the percentage of wormy fruit but not consistently in favor of the bait pan plot. Checks No. 1 and 2 show a higher percentage of injury than the bait pan trees while checks 4 and 5 show a much smaller percentage. Figuring the average per cent for all of the checks and all the bait pan trees, the apparently wormy fruit amounts to about the same, being 29.5% for the checks and 29.9% for the bait pan trees. The checks (No. 1 and 2) that were nearest to the bait pan plot showed the greatest injury. They were in rows adjoining the bait pans where it would seem the pans would have some effect. The other checks, Nos. 3, 4 and 5, were located 11, 17 and 23 rows respectively from the bait pans. Check No. 5 the farthest away had the lowest injury and check No. 4 the next farthest away had the next lowest injury. Why this should be so is not very clear. It seems probable however that it is not due to any effect of the bait pans but rather to the location of the checks in the orchard. Checks No. 1 and 2 were at the edge of the Salway block adjoining the main part of the orchard while the other checks were thirty or forty rows away from the main part of the orchard in the interior of the Salway block.

In connection with the control experiment, work on methods of handling the bait pans was conducted. From May 28th until July 15th, eight rows of the control plot were handled as follows:

1st Series	Row G	Cleaned daily, syrup added twice a week.
	" H	Cleaned once a week, syrup added twice a week.
	" I	Cleaned once every two weeks, syrup added twice a week.
	" J	Cleaned once every month, syrup added twice a week.
2nd Series	" K	Cleaned daily, one tablespoonful of syrup twice a week.
	" M	Cleaned daily, one tablespoonful of syrup once a week.
	" N	Cleaned daily, one tablespoonful of syrup every two weeks.
	" O	Cleaned daily, one tablespoonful of syrup once a month.

In the case of the first series, records were kept of the Oriental moths on the surface only. Other than removing oriental moths from the surface, the pans in rows H, I and J were not disturbed except at the intervals designated. The pans in row G were cleaned daily but only the moths on the surface counted to make the records comparable. In both series, the pans cleaned daily and given syrup twice a week caught the most moths. See Table 4.

TABLE 4. COMPARISON OF METHODS OF HANDLING BAIT PANS

Series	Row	Bait pan treatment	No. of pans	Catch	Avg. per pan
1	G	Pans cleaned daily, syrup twice a week	9	331	36.7
	H	Pans cleaned once a week, syrup twice a week	8	129	16.1
	I	Pans cleaned every two weeks, syrup twice a week	9	224	24.9
	J	Pans cleaned once a month, syrup twice a week	8	148	18.5
2	K	Pans cleaned daily, syrup twice a week	8	344	43.
	M	Pans cleaned daily, syrup once a week	8	293	36.6
	N	Pans cleaned daily, syrup once every two weeks	8	211	26.3
	O	Pans cleaned daily, syrup once a month	8	152	19.

To determine the effectiveness of the pans in attracting moths and learn something of their movements in the orchard, releases of marked

adults were made in the bait pan plot at three different times during the season. Newly emerged adults were placed in wire screen cages and the wings touched with a brush dipped in a solution of alcohol soluble eosin stain. If this is attempted in a glass cage, many moths become fast on the glass but in a screen cage with the open end away from the window the work may be done very quickly and without apparent injury to the moths. Water was supplied to the moths before they were released for fear that more than a normal number might be attracted to the pans through thirst.

On May 25th, 20 ♀s and 20 ♂s were released in the center of the bait pan plot. A few dropped to the ground but most of them flew into the air and were flying with the wind at a height of 8 to 10 feet, sufficient to clear the tops of the trees when last observed. They were in sight for perhaps 75 feet. Of these adults, 2 ♂s were recovered, one on the 28th and one on the 1st of June. One was taken in a tree adjoining the point of release and the other about 100 feet away. Weather conditions were very unfavorable following the release and the rather strong wind blowing at the time may have carried them out of the plot.

On August 16th, 40 ♀s and 30 ♂s were released as before. Of these adults, 11 ♀s and 10 ♂s were recovered over a period of 9 days following the release. This is 30% of the number released. Had the bait pan plot been more extensive, a greater percentage would likely have been recovered. As it was, many no doubt flew out of the plot.

A third release was made on October 4th. Conditions were unfavorable due to rain and of the 27 moths released, but 5 were recovered over a period of 4 days after release. A summary of the releases is given in Table 5.

TABLE 5. SUMMARY OF RELEASES AND CAPTURES OF *L. molesta* ADULTS

Release date	No. released	No. recovered	No. of days from release to last capture
May 28th	40	2	7
August 16th	70	21	9
October 4th	27	5	4

A plan of the plot is given below, showing the point of release and the location of pans catching moths with the numbers caught. Assuming that the highest percentage recovered is somewhere near the percentage taken of the entire moth population, it would seem that little help can be expected of bait pans, especially since many of those caught have time to deposit eggs first.

PLAN OF BAIT PAN PLOT SHOWING RECOVERY OF RELEASED MOTHS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
0		0		0		0		0		03		0		0		0		01
	0		01		01		X		0		0		0		0		0	
0		0		0		X		0		0		01		0		0		0
	0		0		0		0		0		X		0		X		0	
0		0		0		0		0		0		X		0		0		0
	01		0		0		0		0		01		0		0		0	
0		0		0		0		0		01		0		0		X		0
	0		0		0		0		0		0		0		0		01	
0		01		0		0		X		X		0		0		X		0
	0		0		0		0		R		0		01		X		0	
0		0		0		0		02		X		01		0		0		X
	0		0		0		0		0		01		0		0		01	
X		X		0		0		0		0		0		0		0		0
	0		0		0		0		0		X		0		X		0	
0		0		0		0		0		0		0		0		X		0
	0		0		0		0		0		0		X		X		01	
0		0		0		0		0		0		0		X		0		0
	0		01		0		0		0		0		0		0		0	
X		0		0		0		0		01		X		X		0		0

R—Point of release. X—Missing peach trees. 0—Bait pans. The figure indicates the number of moths caught.

AN INVESTIGATION OF SPRAY COVERAGES AND ARSENICAL RESIDUE IN RELATION TO THE CONTROL OF THE CODLING MOTH[1]

By RALPH H. SMITH, *University of California, Citrus Experiment Station, Riverside, California.*

ABSTRACT

During the years from 1920 to 1927, inclusive, extensive laboratory studies with newly hatched codling moth larvae were made and various orchard experiments were performed for the purpose of securing data concerning the effectiveness of control in relation to such factors as: (1) type and character of the spray covering, whether fine-spotted, coarse-spotted, overspray or film; (2) thickness of the covering as revealed by the average amount of As_4O_3 per square centimeter of apple surface; (3) thoroughness of spray application and completeness of covering as revealed by the quantity of spray applied per cubic yard of tree volume; (4) quantity of lead arsenate per hundred gallons of water; (5) weathering off of the poison as revealed by repeated analyses during the season; (6) entrance habits of the newly hatched larva; (7) excessive arsenical residue on the fruit at harvest. An important feature of the in-

[1]Paper No. 179. University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California. Submitted for publication December 20, 1927.

vestigation was the effort made to conduct the experiments with such preciseness as to eliminate to the greatest practicable degree the factors that might contribute to experimental error. The results of the investigation indicate, among other things, that the fine-spotted or "mist" coverage is decidedly the least protective of all, that the protectiveness of any type of coverage varies directly with the amount of arsenic per square centimeter of fruit surface, that the thickness of the film is an important limiting factor in the protectiveness of the film coverage, that overspraying of trees and the use of more lead arsenate than has been recommended in the past are advisable if the maximum effectiveness of the spray is desired, that the completeness of coverage and the amount of arsenic deposited on the fruit vary directly, within certain limits, with the quantity of spray applied per cubic yard of tree volume, that a large percentage of larvae enter the apples unharmed or produce serious injury to the fruit by burrowing directly through the deposit of lead arsenate, and that the efficacy of arsenical sprays in protecting apples against the codling moth has been generally overestimated. Bibliography of 40 titles.

The investigation which this paper briefly summarizes originated in the summer of 1920 when in the course of inspecting an orchard that had been sprayed with calcium caseinate spreader and lead arsenate the writer first observed definite instances in which codling moth larvae had entered apples directly through a film of the poison. The fact that the larvae could do this was at once regarded as a matter of unusual significance because it indicated that the thickness of the spray covering, as well as the completeness of the covering, was a factor in codling moth control. Coincidently, the apple industry in the western states was experiencing considerable commotion as a result of the condemnation of fruit during the previous year on account of excessive arsenical residue. An investigation was outlined, therefore, for the purpose of securing information among other things on such points as (*a*)completeness of spray coverage, (*b*) durability of spray coverage, (*c*) thickness of the spreader film and (*d*) quantity of arsenic on the fruit in relation to the efficacy of lead arsenate in protecting apples against codling moth injury and, also, in relation to excessive arsenical residue on harvested fruit.

Experiments and Observations Made in 1921 and 1922

Many data were secured as a result of analyses of spray residue made with the cooperation of Prof. Ray E. Neidig at the University of Idaho, and as a result of orchard and laboratory experiments conducted during the year 1921, but those data are now considered of minor importance in comparison with the results obtained from more careful and much more exhaustive studies subsequently conducted. One phase of this first work, which deserves special mention, consisted of applying fine-spotted and film coverages of lead arsenate in amounts of 1 lb., 2 lb. and

3 lb. to 100 gal. of water, to nearly mature apples; the spray being applied with a small atomizer.[2] A total of one hundred eight newly hatched codling moth larvae were placed on twelve apples with the average result that 26% of the larvae entered through the fine-spotted coverage and 18% entered through the film coverage. The fact that larvae could enter apples thus ideally covered with spray was so contrary to the dictum which had prevailed generally from the early use of arsenicals in codling moth control that, after discussing the matter with an esteemed friend and former teacher in entomology, I became skeptical as to the reliability of the data. It was suspected that the lead arsenate might have been of a very poor quality. Although Card (5, p. 19, 20), Slingerland (24, p. 20, 56, 57), Simpson (23, p. 32, 88) and Sevastjanov (21) had made observations on the fact that the newly hatched larva rejects the skin of the apple, and Melander (14), (15), (17), also had remarked concerning this behavior, these authorities either definitely stated or left ground for the belief that larvae entering through a distinct deposit of arsenical compound would secure sufficient posion eventually to kill them; at least, during the time that lead arsenate had been in general use, apparently no one had opposed the tenet prevailing universally that the occurrence of wormy apples in sprayed orchards was the result of larvae entering the fruit before the spray was applied or entering at places not actually covered with the insecticide.

The fact that in the experiment above mentioned a much smaller percentage of the larvae entered through the film coverage and that this result was in agreement with the outcome of certain orchard tests conducted in 1921 (25, p. 204), was considered substantial proof that the use of the spreader would result in improved control of the codling moth.[3]

Much to the surprise of many persons, including the writer, the general commercial use of calcium caseinate spreader during 1922 failed to give the marked improvement in codling moth control that was expected. Various possible causes were advanced for this failure, among them being the following: (*a*) that the casein acted as an antidote to the arsenic, (*b*) that the film of poison broke owing to the growth of the fruit and the worms entered at the resultant unprotected areas, (*c*)

[2] "Indestructible" atomizer, purchased of F. Weber Co., Philadelphia.

[3] Subsequent investigations, mentioned in the present paper, demonstrated that the fine-spotted coverage was very much less protective than the coverage of coarse spots, contrary to the belief that had generally prevailed. Therefore, in the experiments made in 1921, the film coverage was compared with the least effective type of spotted coverage, instead of the best as was then supposed.

that the lime in the spreader constituted a diluent which lowered the poisonous value of the lead arsenate, (*d*) that the spreader did not improve the completeness of the spray covering, (*e*) that the film of poison produced by the spreader was too thin.

Orchard and Laboratory Experiments in 1923 and 1924

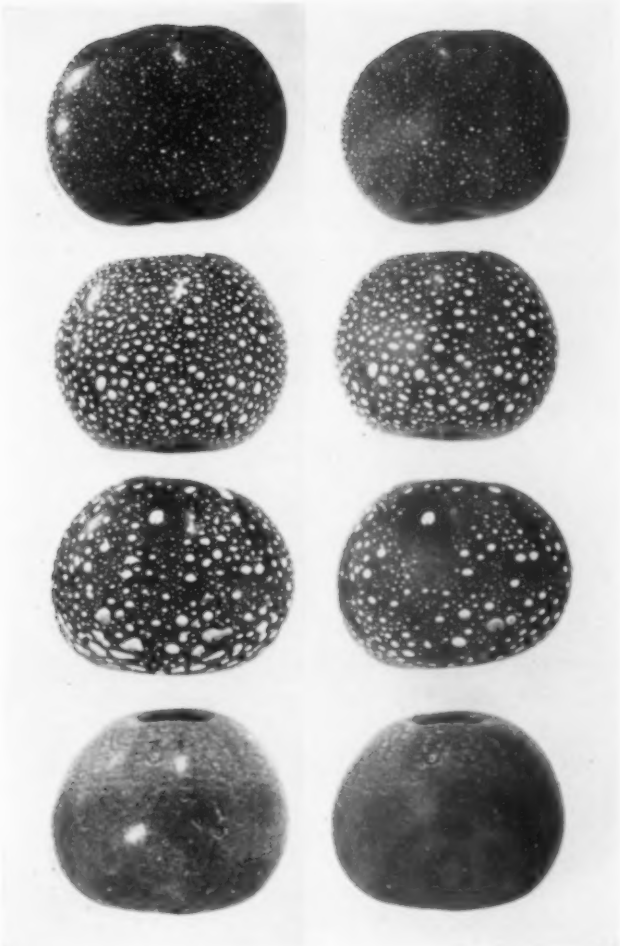
Although experiments were undertaken to secure information on each of the above points, special investigations were made on the thickness of the spray covering. During 1923 orchard experiments in using powdered acid lead arsenate at 2 lb. and 4 lb. to 100 gal. of water, with and without calcium caseinate spreader, were conducted with the cooperation of Prof. J. H. Newton (20) in the Grand Valley of Colorado, where the codling moth occurs in unusual abundance; and similar tests were made under my supervision by twelve leading apple growers in Idaho, Washington, Oregon and California. All trees received drenching quantities of spray. In all of these tests the spray containing four pounds of lead arsenate to 100 gallons of water gave better control than that containing two pounds. On the whole, the spreader resulted in slightly better control than the spray without the spreader, with lead arsenate at 4 lb. to 100 gallons.

During July and August, 1923, laboratory studies were conducted in which over ten thousand newly hatched codling moth larvae, about half of them being from eggs supplied by Mr. W. P. Yetter, Jr., from his insectary at Grand Junction, Colorado (39, p. 32), and the rest secured from Santa Clara and Sonoma Counties, California, were placed on sprayed apples having their calyx cavities previously filled with shellac. The apples were sprayed in the laboratory, compressed air being used to operate the same atomizer employed in the tests of 1921.

Powdered acid lead arsenate was used in amounts of ½, 2, 4 and 8 lb. to 100 gal. of water. Experiments were made with four types of coverages; namely, fine-spotted or "mist," coarse-spotted, overspray and film. Calcium caseinate spreader was used to effect the film coverage. In order to have an estimate of the thickness of the covering of lead arsenate, the surface area of each apple was computed and at the end of the experiments analyses were made to ascertain the average amount of arsenic per square centimeter of apple surface.[4]

The results of the above experiments were reported at several meet-

[4]The methods and technique employed in the experiments are fully described in Hilgardia (Calif. Agr. Exp. Sta.) Vol. 1, No. 17, 1926.



The four types of spray coverages referred to in this article. From top to bottom: film coverage, overspray coverage, coarse-spotted coverage, fine-spotted coverage. Left, apples that received a single application of spray in the laboratory; right, the same apples after receiving a second application of spray. There was a tendency for the drops of the second application to form on the deposits of the first.

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ings[5] and were discussed with a score or more persons of recognized authority on spraying and codling moth control; and the general attitude of those persons was that the findings needed further verification. Under the circumstances the laboratory experiments, supplemented by certain technical orchard tests, were repeated on a still larger scale and with added refinements in technique at the University of California during July and August, 1924. The results, which have been published in detail (31), were essentially the same as those obtained the previous year.[6] The outstanding facts, as indicated by the accompanying graphs, were that (*a*) the lead arsenate was far less effective in protecting the apples than theretofore had been believed; (*b*) the fine-spotted coverage proved to be decidedly inferior to the coarse-spotted coverage; (*c*) at the usual concentration of 2 lb. of lead arsenate to 100 gal. of water, the film coverage gave about the same protection as the coarse-spotted coverage; (*d*) in all of the coverages the protection varied directly with the thickness of the poison covering.

Evaluation of the Experimental Data

A considerable part of the year 1925 was spent in reviewing more carefully than previously the literature on codling moth control and in making orchard observations in various localities in California and Oregon, for the purpose of reaching a conclusion regarding the relation of the data obtained in the research above mentioned to the practical control of the codling moth in apple orchards. Finally, a series of articles were prepared for publication which contained among other carefully weighed statements, the following: "The efficacy of lead arsenate in protecting apples against injury *has been overestimated*" (29, p. 6); "the recommendation that apples should be covered with fine particles of spray is based on theory, and the theory is erroneous" (34, p. 7); "The more poison on the leaves, bark and apples, the more worms will be killed. . . if worms are bad it will pay well to double the amount of poison" (34, p. 7). Overspraying was advised if the maximum effectiveness of the spray was needed.[7] The practical appli-

[5]Among the meetings were the Fifth Annual Conference of Northwestern Horticulturists, Entomologists and Plant Pathologists at Boise, Idaho, July, 1923; the annual meeting of the Connecticut Pomological Society at Hartford, Conn., November, 1923; the Farmers' and Fruit Growers' Institute at Provo, Utah, January, 1924; the annual meeting of the Pacific Division of the A.A.A.S. at Stanford University, Calif., June, 1924 (26).

[6]The experiments of 1923 were performed in the laboratories of the Golden State Milk Products Company, San Francisco. Mr. Henry W. Dixon of Berkeley, Calif., assisted with the work, especially with the arsenic determinations.

[7]See also bibliographical references (28) (32) (33) (35) (36).

TABLE 1. SHOWING THE AVERAGE SURFACE AREA PER APPLE, THE AVERAGE MILLIGRAMS OF As_2O_3 PER APPLE, THE AVERAGE MICROGRAMS (μg.) PER SQUARE CENTIMETER OF APPLE SURFACE, AND THE AVERAGE GRAINS OF As_2O_3 PER POUND OF APPLES AS ASCERTAINED BY MEASUREMENTS AND ANALYSES MADE BEFORE AND AFTER EACH COVER SPRAY AND AT HARVEST. THE TABLE ALSO SHOWS THE AVERAGE MICROGRAMS OF As_2O_3 IN THE OUTER AND THE INNER CALYX CUPS, AND THE PERCENTAGE OF APPLES INJURED BY WORMS IN THE BLOCKS OF APPLE TREES RECEIVING DIFFERENT SPRAY TREATMENTS

Time of making analyses		Block 1: 1st calyx spray, lead arsenate 2½ lb.–100 gal. 2nd calyx spray, lead arsenate 2½ lb.–100 gal. 5 cover sprays, lead arsenate 4 lb.–100 gal. and hydrated lime[1] 1 lb.–100 gal.				Block 2: 1st calyx spray, lead arsenate 2½ lb.–100 gal. 2nd calyx spray, lead arsenate 2½ lb.–100 gals. 5 cover sprays, lead arsenate 3 lb.–100 gal. and fish oil[2] ½ gal.–100 gal.			
		Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg	As_2O_3 per pound grains	Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains
Before 2nd cover spray	May 18	32.2	.09	2.8	.037	32.2	.125	3.8	.054
After 2nd cover spray	May 19	38.8	.375	9.1	.113	34.2	.385	11.2	.158
Before 3rd cover spray	June 3	45.4	.185	4.1	.044	50.2	.262	5.2	.059
After 3rd cover spray	June 5	47.8	.650	13.7	.152	45.4	.588	12.9	.152
Before 4th cover spray	July 7	91.6	.656	7.2	.052	88.2	.532	6.1	.052
After 4th cover spray	July 10	95.0	1.186	12.5	.103	95.0	1.338	10.9	.092
Before 5th cover spray	July 29	116.8	1.226	10.4	.079	116.8	1.061	9.1	.068
After 5th cover spray	July 30	120.8	1.572	13.0	.076	128.7	1.898	15.2	.073
At harvest	Sept. 14	144.3	.690	4.8	.032	132.7	1.212	9.1	.067
Average		81.4	.737	8.6	.076	80.3	.822	9.3	.086
As_2O_3 in calyx:									
Inner cup, μg.				4.7				3.3	
Outer cup, μg.				19.3				23.3	
Total				24.0				26.6	
Percentage of apples injured by worms				35.3				32.7	

[1]The brand of lead arsenate used in this test contained a small quantity of casein to improve the spreading of the spray. The manufacturer recommended adding hydrated lime, this serving to dissolve the casein.

[2]This was a rather crude grade of fish oil. It was added to improve the spreading and sticking quality of the spray.

Time of making analyses		Block 3				Block 4			
		Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains	Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains
Before 2nd cover spray	May 18	32.2	.09	2.8	.037	32.2	.125	3.8	.054
After 2nd cover spray	May 19	38.8	.375	9.1	.113	34.2	.385	11.2	.158
Before 3rd cover spray	June 3	45.4	.185	4.1	.044	50.2	.262	5.2	.059
After 3rd cover spray	June 5	47.8	.650	13.7	.152	45.4	.588	12.9	.152
Before 4th cover spray	July 7	91.6	.656	7.2	.052	88.2	.532	6.1	.052
After 4th cover spray	July 10	95.0	1.186	12.5	.103	95.0	1.338	10.9	.092
Before 5th cover spray	July 29	116.8	1.226	10.4	.079	116.8	1.061	9.1	.068
After 5th cover spray	July 30	120.8	1.572	13.0	.076	128.7	1.898	15.2	.073
At harvest	Sept. 14	144.3	.690	4.8	.032	132.7	1.212	9.1	.067
Average		81.4	.737	8.6	.076	80.3	.822	9.3	.086
As_2O_3 in calyx:									
Inner cup, μg.				4.7				3.3	
Outer cup, μg.				19.3				23.3	
Total				24.0				26.6	
Percentage of apples injured by worms				35.3				32.7	

Time of making analyses		Block 3: 1st calyx spray, lead arsenate 2½ lb.–100 gal. 2nd calyx spray, lead arsenate 2 lb.–100 gal. 5 cover sprays, lead arsenate 4 lb.–100 gal. and calcium caseinate[3] 1 lb.–100 gal.				Block 4: 1st calyx spray, lead arsenate 2 lb.–100 gal. Triona[4] 2½ gal.–100 gal. and calcium caseinate 1 lb.–100 gal. 2nd calyx spray, same as first calyx spray. 5 cover sprays, same as first calyx spray.			
		Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. µg.	As_2O_3 per pound grains	Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. µg.	As_2O_3 per pound grains
Before 2nd cover spray	May 18	36.3	.112	3.1	.036	36.3	.130	3.6	.041
After 2nd cover spray	May 19	34.2	.325	9.1	.129	34.2	.251	7.4	.089
Before 3rd cover spray	June 3	47.8	.270	5.6	.063	45.4	.226	5.0	.054
After 3rd cover spray	June 5	45.4	.431	9.5	.117	43.0	.374	8.9	.086
Before 4th cover spray	July 7	98.5	.576	5.9	.049	81.7	.512	6.3	.055
After 4th cover pray	July 10	88.2	1.064	12.3	.104	91.6	1.086	11.9	.099
Before 5th cover spray	July 29	120.8	1.050	8.7	.066	120.8	.871	7.2	.058
After 5th cover spray	July 30	132.7	1.810	13.9	.105	128.7	1.618	12.9	.095
At harvest	Sept. 14	149.8	.905	6.1	.042	162.9	1.436	8.8	.059
Average		83.7	.727	8.2	.079	82.7	.723	8.0	.071
As_2O_3 in calyx:									
Inner cup, µg.				4.0				2.0	
Outer cup, µg.				22.0				19.3	
Total				26.0				21.3	
Percentage of apples injured by worms				35.2				34.9	

[3]The calcium caseinate consisted of approximately 75% of finely ground casein and 25% calcium hydrate.

[4]Triona is the trade name of an oil emulsion made of a fairly highly refined petroleum oil.

TABLE 1.—*Continued.*

Time of making analyses		Block 5 1st calyx spray, omitted 2nd calyx spray, paste lead arsenate[5] 6 lb.–100 gal. and calcium caseinate 1 lb.–100 gal. 5 cover sprays, same as second calyx spray Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains	Block 6 1st calyx spray, lead arsenate 2 lb.–100 gal. 2nd calyx spray, lead arsenate 2 lb.–100 gal. 5 cover sprays, lead arsenate 2 lb.–100 gal. Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains
Before 2nd cover spray	May 18	38.8	.088	2.3	.029	36.3	.065	1.8	.022
After 2nd cover spray	May 19	28.3	.176	6.2	.073	34.2	.141	3.9	.047
Before 3rd cover spray	June 3	47.8	.172	3.8	.040	47.8	.128	2.8	.030
After 3rd cover spray	June 5	45.4	.312	6.9	.075	45.4	.279	6.2	.064
Before 4th cover spray	July 7	88.2	.444	5.0	.043	85.0	.326	3.6	.034
After 4th cover spray	July 10	98.5	.912	9.2	.078	85.0	.690	8.5	.069
Before 5th cover spray	July 29	116.8	.988	8.2	.064	120.8	.840	6.9	.054
After 5th cover spray	July 30	136.8	1.890	13.9	.100	136.8	.984	7.2	.051
At harvest	Sept. 14	153.9	1.315	8.2	.058	141.0	.763	4.7	.032
Average		83.8	.700	7.8	.062	81.3	.457	5.1	.045
As_2O_3 in calyx:									
Inner cup, μg.				2.3				1.7	
Outer cup, μg.				6.6				12.0	
Total				8.9				13.7	
Percentage of apples injured by worms				27.3				31.4	

[5]The paste lead arsenate contained approximately 50 per cent of water by weight.

[5]The paste lead arsenate contained approximately 50 per cent of water by weight.

Time of making analyses		Block 7: 1st calyx spray, lead arsenate 4 lb.–100 gal. 2nd calyx spray, lead arsenate 4 lb.–100 gal. 5 cover sprays, lead arsenate 4 lb.–100 gal.				Block 8: 1st calyx spray, lead arsenate 2 lb.–100 gal. 2nd calyx spray, lead arsenate 2½ lb.–100 gal. 5 cover sprays, lead arsenate 4 lb.–100 gal., and wheat flour[6] 2 lb.–100 gal.			
		Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains	Area per apple sq. cm.	As_2O_3 per apple mg.	As_2O_3 per sq. cm. μg.	As_2O_3 per pound grains
Before 2nd cover spray	May 18	36.3	.102	2.9	.034	——	——	——	——
After 2nd cover spray	May 19	38.8	.279	7.2	.083	34.2	.169	4.9	.059
Before 3rd cover spray	June 3	45.4	.177	3.9	.040	47.8	.238	4.9	.054
After 3rd cover spray	June 5	47.8	.470	9.8	.101	45.4	.518	11.4	.133
Before 4th cover spray	July 7	85.0	.530	6.2	.053	85.0	.392	4.6	.040
After 4th cover spray	July 10	91.6	1.166	12.8	.112	91.6	.656	7.2	.061
Before 5th cover spray	July 29	116.8	1.238	10.6	.082	124.7	.636	5.1	.038
After 5th cover spray	July 30	136.8	1.226	9.0	.065	136.8	.842	6.2	.047
At harvest	Sept. 14	144.3	1.124	8.6	.057	162.9	.704	4.3	.027
Average		82.5	.714	7.9	.070	91.0	.462	5.4	.057
As_2O_3 in calyx:									
Inner cup, μg.				3.3			No calyx analyses made		
Outer cup, μg.				18.0					
Total				21.3					
Percentage of apples injured by worms				32.9			49.2		

[6]The flour was added to determine its effect on the spreading of the spray and the amount of lead arsenate deposited on the fruit.

cation of the findings was also discussed at several meetings of importance, including that of the Pacific Division of the A.A.A.S. at Portland, Ore. in June, 1925, and the annual meeting of the A.A.A.S. at Kansas City in December, 1925 (30).

Nevertheless, it was recognized that there was need of securing from orchard experiments more exact and specific information concerning the above points than any such experiments had yet furnished; and studies with this purpose in mind were conducted during the years 1926 and 1927.

Orchard Experiments Made in 1926 and 1927

During 1926 an experiment was performed with the generous cooperation of Mr. Frank B. Herbert, Deciduous Fruit Entomologist of Balfour, Guthrie Co., in which two calyx sprays and five cover sprays were applied to each of eight different blocks of apple trees in a badly infested but well cared-for orchard near San Jose, California. Fifty apples were picked from each block immediately before and immediately after the second and third cover sprays, and, similarly, twenty-five were picked from each block before and after the fourth and fifth cover sprays and just before harvest. After the apples had been measured and weighed, the spray was dissolved off and analyses made for the purpose of ascertaining the average quantity of arsenic per square centimeter of apple surface and the average quantity of arsenic per pound of fruit, in relation to (*a*) the different spray materials, (*b*) the growth of the fruit in weight and surface area, (*c*) the weathering off of the spray and (*d*) the injury caused by the codling moth. Analyses also were made to determine the average quantity of arsenic in the calyx cups of the apples.

The more important results from this experiment are given in Table 1. A discussion of the methods and technique employed and the many factors pertaining to accuracy in the investigation must await a more extensive paper. It will suffice to note that the analyses prove that the fruit was heavily covered with lead arsenate throughout the season, although the percentage of apples injured by worms ranged from 27.3% to 49.2% among the different blocks.

Worm Injuries in Relation to Spray Deposits

A special study was conducted in the badly infested district at Yucaipa, California, for the purpose of determining whether larvae enter sprayed apples between the deposits of poison, at cracks in the deposits

which may result from the growth of the fruit or at parts of the surface not reached in the application of the spray; or whether the entrances are made directly through the poison. In an orchard receiving five drenching cover sprays, worm-injured apples were picked before the third and fifth cover sprays and at harvest, and microscopic examinations made of such holes extending at least through the skin as had been made, as nearly as could be judged, by larvae between the time of the last preceding spray and the time of examination. The facts obtained in this study are summarized in Table 2. Approximately 20% and 90% of the entrances in the spotted coverage and film coverage, respectively, were effected by the larvae burrowing through the deposit of lead arsenate.

TABLE 2. SUMMARY OF THE RESULTS OF STUDIES MADE TO DETERMINE THE PLACES OF ENTRANCE OF LARVAE INTO SPRAYED APPLES IN RELATION TO SPRAY DEPOSITS

Time of making examination	Number of holes examined	Coarse-spotted and overspray coverage: Holes made on part of surface missed by spray	Holes made more or less distinctly between deposits of spray	Holes made definitely through deposits of spray	Place of holes too uncertain to classify
		per cent	*per cent*	*per cent*	*per cent*
Before 3rd cover spray	93	2.2	45.2	19.4	33.3
Before 5th cover spray	66	0	34.9	16.6	48.4
At harvest	112	0	48.2	35.7	16.1
	Spray applied with fish-oil-soap spreader; i. e., film coverage				
Before 3rd cover spray	16	18.7	0	75	6.3
Before 5th cover spray	10	0	0	100	0
At harvest	22	0	0	90.9	9.1

It was not possible to distinguish definitely between entrances and stings because many larvae in excavations just beneath the skin probably had swallowed poison and would have died had they not been destroyed when the apples were examined.

QUANTITY OF SPRAY APPLIED PER CUBIC YARD OF TREE VOLUME IN RELATION TO COMPLETENESS AND THICKNESS OF COVERAGE

The conclusion was reached that the most practicable measure of thoroughness in spraying trees is the quantity of spray applied per unit

of tree volume with a given type of spray nozzle discharging spray at a given rate under a given pressure. An experiment was performed in which, at the time of the first cover spray, 6, 12 and 18 gallons of spray were applied to different trees, each tree measuring 42 feet over the top and 65 feet around, or approximately 16 feet high and 21 feet in diameter; the volume being 144 cubic yards;[8] i.e., approximately ⅓, ⅔ and 1 pint of spray per cubic yard of tree volume were applied in the different tests. The spray was applied from the outside of the trees (the trees were not sprayed from their centers) with a spray gun discharging three gallons per minute under a pressure at the gun of 300 pounds. Powdered acid lead arsenate was used at 8 lb. to 100 gal. of water.

Immediately after the spray had dried, 150 apples were picked and scored as to coverage, and after that they were measured and analyser made to ascertain the average amount of arsenic per square centimetes of surface. The data on the completeness of coverage shown in Table 3 and the data on the arsenic per square centimeter shown in Table 4, are derived from spray applied without spreader. The data indicate that drenching quantities of spray must be applied in order to obtain the maximum coverage and the greatest deposition of lead arsenate.

TABLE 3. EXTENT OF SPRAY COVERING ON APPLES, RESULTING FROM THE APPLICATION OF ⅓, ⅔ AND 1 PINT OF SPRAY PER CUBIC YARD OF TREE VOLUME[1]

	Percentage of apples with spray distributed over less than 50% of their surfaces	Percentage of apples with spray distributed over approximately 50% to 95% of their surfaces	Percentage of apples rated as having their surfaces completely covered
⅓ pint per cu. yd. (6 gal per tree)	76.6	23.3	0.0
⅔ pint per cu. yd. (12 gal. per tree)	32.0	50.6	17.3
1 pint per cu. yd. (18 gal. per tree)	21.2	32.0	46.0

[1]The fact should be emphasized that the so-called "invisible" or "barely visible" form of covering of lead arsenate was ignored in making the records for Table 3.

[8]The formula $V = \frac{C^2}{4\pi}\left(\frac{O}{2} - 0.144\ C\right)$ was used in calculating the volume; this being the formula employed in the fumigation of citrus trees (37, p. 25). V = volume, C = circumference and O = the distance over the tree.

TABLE 4. QUANTITY OF ARSENIOUS OXIDE PER SQUARE CENTIMETER ON APPLES, RESULTING FROM THE APPLICATION OF ⅓, ⅔ AND 1 PINT OF SPRAY PER CUBIC YARD OF TREE VOLUME, USING POWDERED ACID LEAD ARSENATE AT 8 LB. TO 100 GAL. OF WATER[1]

	Micrograms of As_2O_3 per sq. cm.
⅓ pint per cu. yd. (6 gal per tree)	23.4
⅔ pint per cu. yd. (12 gal. per tree)	43.9
1 pint per cu. yd. (18 gal. per tree)	48.8

[1]The quantity of As_2O_3 per sq. cm. is higher than other studies (31) would indicate as correct for one application of spray at this concentration. This may have been caused in part by the fact that the calyx spray was applied late and some arsenic was deposited on apples by that spray.

ORCHARD EXPERIMENT ON THE PROTECTION AFFORDED BY FINE-SPOTTED AND COARSE-SPOTTED COVERAGES

A single tree 15 feet high and 21 feet in diameter was given one calyx and five cover sprays; the spray being applied with a spray gun discharging three gallons per minute under 300 pounds pressure at the gun and the sprayman standing sufficiently far away from the tree so that only the drifting, "fog" part of the spray reached the tree. Four and one-half gallons of spray was thus applied in each of the five applications. The surrounding trees each received 12 gallons of spray in each of five applications; i.e., they were decidedly oversprayed with the sprayman standing close enough so that the spray carried with force through the centers of the trees. Counts made at harvest showed that 89.4% of the apples were worm-injured on the tree having the fine-spotted coverage and 24% were injured on the heavily sprayed trees. It is recognized that the above experiment was very limited, but the spray was applied in such a manner and other influencing factors were such that the results are regarded as dependable.

ORCHARD EXPERIMEMT IN USING LEAD ARSENATE AT 1 LB. AND 4 LB. TO 100 GAL. OF WATER

At Yucaipa, California, twenty apple trees averaging 10 feet high and 16 feet in diameter were given three cover sprays, 7½ gallons of spray being applied to each tree at each application with a spray gun discharging 3 gallons per minute under 300 pounds pressure. Potash fish-oil soap was used as a spreader. Powdered acid lead arsenate was used at 1 lb. to 100 gal. of water on ten of the trees, and on the other ten

trees the poison was used at 4 lb. to 100 gal. Examinations made August 20 revealed that 36% of the apples on the trees receiving the light concentration of spray had been entered by worms apparently unharmed while only 18% of the apples on the trees receiving the heavy concentration of spray had been thus entered by worms.

Conclusions

The investigation summarized in this paper tends to indicate that certain conceptions long held concerning spraying with arsenical compounds to control the codling moth are partially or wholly erroneous. It is somewhat puzzling to understand how such a situation could exist because we, as entomologists, have supposed that our recommendations and advice were adequately grounded on hundreds of experiments performed by scores of persons over a period of nearly fifty years. An analysis of the problem suggests that, in general, the methods and pro-

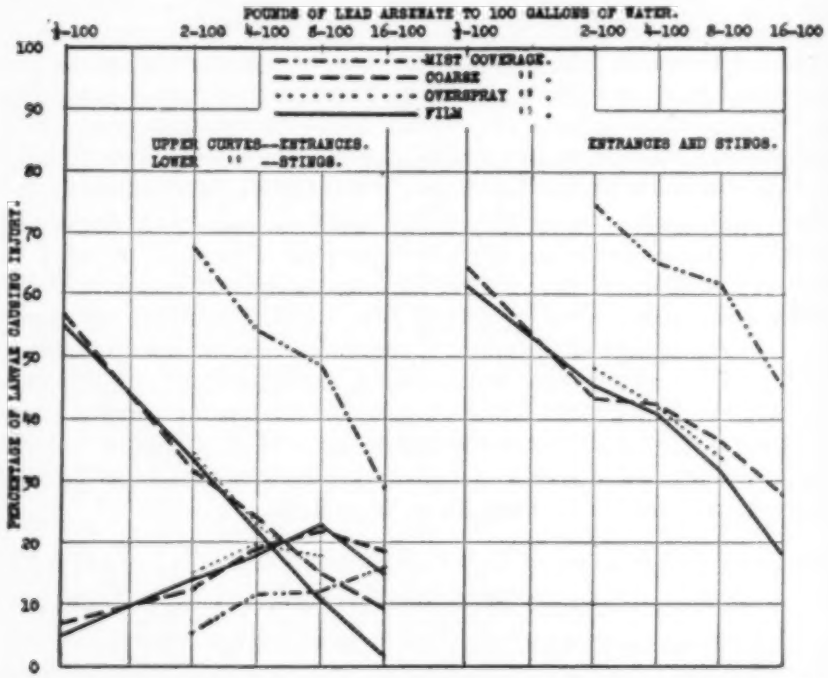

Fig. 38. Curves based on laboratory experiments involving the use of 374 apples and 9350 newly hatched codling moth larvae. The curves indicate the percentage of larvae producing injury to apples sprayed with powdered acid lead arsenate in amounts of ½, 2, 4, 8 and 16 lbs. to 100 gal. of water, with different types of spray coverages.

cedures followed in orchard spraying experiments have not been sufficiently exact to establish the true status of some of the factors dealt with in this paper. When confronted with data more or less contradictory and inconclusive, as frequently has been the case, authorities have preferred to adhere to the theory and presupposed facts. They have assumed that the "erratic" data were the result of experimental error but have failed to recognize that an equal measure of the "positive" data likewise should be regarded as the result of experimental error.

The investigation indicates that the degree of protection varies directly with the concentration of the spray and with the amount of

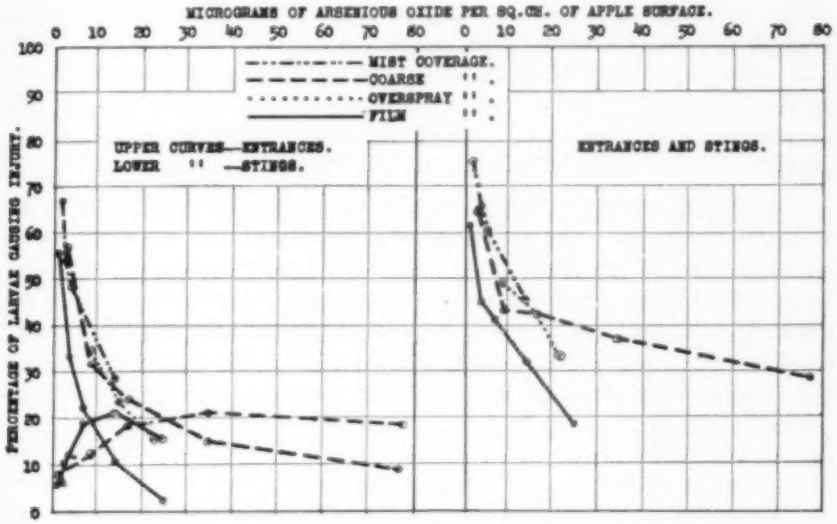

Fig. 39. Curves based on the experiments referred to in figure 2, indicating the percentage of larvae injuring apples in relation to the micrograms of arsenious oxide per square centimeter of apple surface, in the case of different types of spray coverages.

lead arsenate on the fruit; that is, the thickness of the covering is an important factor in protectiveness. In this connection it may be noted that during the past year there has been a tendency to advise the use of three and four pounds of powdered lead arsenate to 100 gallons of water (9, p. 2, 3) (10, p. 161) (40, p. 60, 466) (11, p. 22) (8, p. 110, 111), which is quite contrary to evidence and advice previously available (2, p. 16) (3, p. 16) (12, p. 5, 18) (13, p. 18) (14, p. 18) (19, p. 14) (38, p. 41).[9]

[9]The latter references and also the following ones pertaining to the "mist" type of coverage, are by no means a complete list.

The fine spotted or "mist" type of coverage is shown to be decidedly less protective than the coarse spotted coverage, a fact quite opposed to the evidence and recommendations heretofore generally prevailing (1, p. 18, 27) (4, p. 65) (6, p. 44) (7, p. 79, 80, 81) (18, p. 323) (19, p. 18) (22, p. 9, 29, 35).

In order to even approximate the complete coverage of all the apples of a tree with coarse spots, or with a film in case a spreader is employed, and in order to place the maximum amount of the protective compound on the fruit, it is necessary to apply drenching quantities of spray to the tree. The completeness of coverage and the thickness of the coverage, within limits, vary directly with the quantity of spray applied per cubic yard of tree volume.

A large percentage of larvae are able to enter apples unharmed or produce marked injury to the fruit by burrowing directly through the film covering and deposits of lead arsenate. The idea generally expressed that complete coverage of the fruit with lead arsenate will result in the complete destruction of all the larvae attempting to enter the fruit is erroneous. Several persons have raised the question as to whether the codling moth larvae involved in this research may have developed a tolerance for arsenic. Although the question is one that deserves consideration, the writer believes that the apparently puzzling condition revealed by the investigation can be largely explained through the proper interpretation of experimental data available in the literature on the codling moth.

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A COMPARISON BETWEEN COMPLETE AND INCOMPLETE DIGESTION OF SPRAYED APPLE FOLIAGE IN DETERMINING ARSENIC BY THE GUTZEIT METHOD[1]

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ABSTRACT

Quantitative analyses of arsenic by the Gutzeit method on sprayed apple leaves have shown that partial digestion of the dried plant tissue with dilute nitric or hydrochloric acid gives as accurate results as complete digestion with concentrated sulphuric and nitric acids. The incomplete digestion method consumes considerably less time and costs less than the complete digestion method.

INTRODUCTION

The Gutzeit Method is universally used in determining arsenic. It is very sensitive to arsenic and, if proper precautions are taken, such minute quantities as 1 part A_2O_3 to three millions of solution can be readily detected by it. This method depends primarily upon the evolution of arsine (AsH_3) from arsenic compounds (2) by nascent hydrogen liberated under the action of zinc. The evolved arsine reacts with $HgCl_2$

[1]Paper of the Journal Series of the New Jersey Agricultural Experiment Stations, Department of Entomology.

or $HgBr_2$, forming a darkish-yellow compound, the color-intensity of which is directly proportional to the amount of arsine liberated, and of course, to the concentration of arsenic in the sample. For this purpose the arsenic must first be freed from the organic matter and brought into solution. The usual procedure is to digest the organic matter with concentrated sulfuric and nitric acids until all of it is dissolved. This process takes from three to six hours, depending on the kind of organic matter present in the sample to be analyzed, and is accompanied with offensive fumes from the nitric and sulfuric acids.

While studying the problem of "Stickers and Dilutents" it became necessary to determine arsenic on apple foliage sprayed with $PbHAsO_4$ mixture. During these analyses it occurred to the writer that the time consumed in completely digesting the plant tissue as outlined in the Official Methods of the Agricultural Chemists (1), could be considerably shortened if it should be possible to dissolve out all of the $PbHAsO_4$ from the plant material. Among the several reagents in which lead arsenate dissolves readily, dilute solutions of nitric and hydrochloric acids, and sodium hydroxide suggested themselves.

Methods

Preliminary tests have shown that $PbHAsO_4$ dissolves very rapidly in dilute HNO_3 (5% to 10%) leaving a clear solution. This should be expected since the $Pb(NO_3)_2$ formed in the reaction is very soluble in water. The addition of NaOH to $PbHAsO_4$ resulted in a turbid mixture, due to the $Pb(OH)_2$ formed, which cleared up, however, upon heating. When HCl was used a heavy precipitation of $PbCl_2$ resulted which dissolved upon heating and reappeared upon cooling in form of long, needle shaped crystals. In order to determine whether or not all of the As_2O_3 can be recovered from $PbHAsO_4$ when treated with the above reagents the following experiment was carried out. Several 0.2 gm. samples of $PbHAsO_4$ alone and mixed with 1 gm. of unsprayed apple foliage were transferred to 250 c.c. beakers. The samples were then treated with 25 c.c. of one of the following solutions, 10% HNO_3, 10% HCl, 20% HCl, 10% NaOH. In a similar way 1 gm. samples of sprayed apple foliage were prepared. The mixtures were boiled for about 30 minutes under the hood with frequent stirring until the sample containing organic matter became a thick pulp and most of the HNO_3 and HCl was eliminated. The pulpy mass was then diluted, filtered and washed several times with hot distilled water. The volume of the filtrate was made up to 100 c.c. and 1 c.c. aliquots were taken for arsenic analyses. The modified Gutzeit Method as outlined in Scott (2) was

used. Alongside with the above determinations two samples of sprayed apple foliage were completely digested with concentrated nitric and sulfuric acids and were analyzed for As_2O_3.

It may be well to mention here that all the chemicals (except the NaOH which consisted of the usual C. P. sticks, obtained from Eimer & Amend) used were arsenic "free". Precautions were also taken to add the same quantities of reagents to each sample and to select uniform strips of $HgBr_2$ paper. The last item is very important because the length and intensity of the color stain will be influenced by the texture and width of the strips.

Experimental

The results presented in Table 1 show that all of the As_2O_3 can be recovered from $PbHAsO_4$ when used either alone or when mixed with leaf tissue by partial digestion with either 10% HNO_3 or with 20% HCl. Furthermore, the amount of As_2O_3 found on sprayed foliage when digested with either one of the above two reagents was practically the same as that recovered by the complete digestion method. The results obtained with 10% HCl were not as constant as those obtained with the 20% HCl. When the organic matter containing $PbHAsO_4$ was treated with 10% NaOH the quantities of As_2O_3 determined were considerably higher than those obtained by complete digestion.

Table 1. As_2O_3 Recovered from $PbHAsO_4$ and from Dried, Ground Apple Leaves Mixed or Sprayed with $PbHAsO_4$. Results in mgm.

Sample No.	Composition of sample	As_2O_3 mgm. added	Reagents 10% HNO_3	10% HCl	20% HCl	10% NaOH	Complete Digestion[1]
1	0.2 gm. $PbHAsO_4$	56 mgm.	58	52	55	54	—
2	1 gm. unsprayed apple leaves 0.2 gm. $PbHAsO_4$	56 mgm.	54	50	54	65	—
3	1 gm. sprayed apple leaves	———	0.375	0.350	0.368	0.85	0.375
4	1 gm. sprayed apple leaves	———	1.25	1.20	1.30	1.85	1.25
5	1 gm. sprayed apple leaves	———	1.20	1.00	1.20	1.60	1.10
6	Blank 1 gm. unsprayed apple leaves	trace	trace	trace	trace	.0005 to .001	trace

[1]Official methods

In order to obtain some further data on the accuracy of the incomplete digestion method, ten different batches of apple leaves, which had been sprayed with sulfur lime dry mix containing 1.5 lbs. of $PbHAsO_4$ per 50 gallons of spray, were selected for testing. Two sets of analyses were run. Duplicate 1 gm. samples of the dried, pulverized apple leaves were completely digested in the first set with concentrated nitric and sulfuric acids and incompletely digested in the second set with 10% nitric acid. Averages of the duplicate analyses are presented in Table 2.

TABLE 2. AMOUNTS OF As_2O_3 RECOVERED FROM 1 GM. OF SPRAYED APPLE LEAVES BY BOTH COMPLETE AND INCOMPLETE DIGESTION METHODS

Sample No.	Complete Digestion As_2O_3 mgm.			Incomplete Digestion As_2O_3 mgm.		
	1	2	Average	1	2	Average
7	1.20	1.25	1.25	1.25	1.15	1.20
8	1.10	1.10	1.10	1.20	1.15	1.17
9	1.25	—	1.25	1.20	1.20	1.20
10	1.15	1.05	1.10	1.15	1.25	1.20
11	0.45	0.45	0.45	0.45	0.45	0.45
12	0.35	0.35	0.35	0.45	0.35	0.40
13	0.75	0.75	0.75	0.75	0.75	0.75
14	0.55	0.55	0.55	0.55	0.55	0.55
15	0.35	0.35	0.35	0.25	0.25	0.25
16	1.05	0.95	1.00	1.05	0.85	0.95

A comparison of the results secured from the two sets of analyses do not reveal any appreciable differences between the amounts of arsenic recovered from the apple leaves by the two methods. The variations observed are not in any way greater than those usually encountered between duplicate analyses of the same sample and can be included within the limits of experimental error.

It appears, therefore, from the data obtained in the above experiments that arsenic present on sprayed apple foliage can be completely recovered by subjecting the finely ground plant material to partial digestion with either 10% HNO_3 or 20% HCl. Digesting the apple leaves with dilute acids presents several advantages over the complete digestion.

(1) It reduces the time consumed in the complete digestion to about one hour.

(2) It eliminates the offensive fumes from the concentrated sulfuric and nitric acids.

(3) It costs less.

SUMMARY

Two methods of digesting sprayed apple foliage for arsenic analysis were tested out. In the first method the finely pulverized plant tissue was subjected to complete digestion with concentrated HNO_3 and H_2SO_4 until all the organic matter was in solution. In the second method the plant material was boiled with either 10% HNO_3 or with 20% HCl for about thirty minutes, filtered and washed. Chemical analyses have shown that the amounts of As_2O_3 recovered from the thus partially digested plant material were practically the same as those recovered from the completely digested plant material.

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AN EXPERIMENT IN TRAPPING CUTWORMS

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ABSTRACT

7703 cutworms were collected in traps at Waltham between April 27 and July 17, 1927. Chickweed sods were used as traps in the largest experiment where 6627 cutworms were collected but shallow trays with a screen bottom when baited with chickweed proved to be as effective and were more easily handled. The cutworms in Group 3 which included *Euxoa ochrogaster*, *Euxoa tessellata*, and *Euxoa perpolita* comprised 94.34% of the larvae collected. *Agrotis fennica* and *Agrotis unicolor* were trapped in noticeable numbers. Rain and general cold cloudy weather noticeably decreased the numbers of cutworms collected while temperature variations had a less noticeable influence.

While collecting garden cutworms in traps for insectary studies at Waltham in the spring of 1927, it was apparent that, if the collections were made at regular intervals, the records would indicate the periods of seasonal abundance of the cutworms and to a lesser degree their migratory habits and their reaction to climatic changes. Three trapping experiments in which the traps were examined at 2 and 3 day intervals resulted in the collection of 7703 cutworms.

The majority of the cutworms were collected in a field 100 feet long and 36 feet wide in which sod had been plowed under, August 4, 1926. As shown in Fig. 41 the field was surrounded on the east and south by grassland and on the north and west by cultivated land. On April 25, 1927 it was harrowed and fifty sods of chickweed (about 8 inches in

diameter) were placed in 5 rows running lengthwise in the field. The rows were 6 feet apart and the sods 9 feet apart in the rows. Chickweed was selected as bait because it was readily available and could be handled easily although it seems reasonable that fresh greens such as clover, lettuce or spinach would be equally satisfactory.

The cutworms were collected by shaking them from the sod and by picking them from the soil under and adjacent to the sod. During the prevailing wet weather of May and June 1927 the chickweed sod remained fresh for 10 to 14 days in spite of up-rooting at each examination but during periods of hot dry weather it was necessary to renew the sods in 3 or 4 days. A few times some of the sods were scratched and scattered over the field by pheasants, a male bird being observed doing this once, and numerous skunk tracks indicated that these animals were interested undoubtedly from a gastronomical standpoint, but for the most part the traps were unmolested.

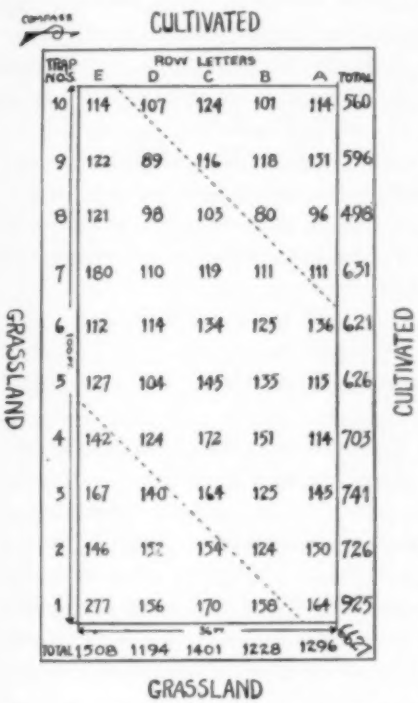

FIG. 40.—Diagram showing the number of cutworms collected in traps, 1927.

In Fig. 40 is shown the number of cutworms collected in each of the 50 chickweed traps. The largest number 277 was taken from Trap E-1 in the southeast corner and the smallest number 80 from Trap B-8. Collections were made in this field from April 27 to July 1 and the total number collected was 6627 for an average of 132.54 cutworms per trap.

Although the summer-plowed land provided ideal conditions for oviposition by certain species of cutworm moths, it is unreasonable that 6627 cutworms were located in 3600 square feet of cultivated land and could be collected in varying numbers over a period of nine weeks. Therefore, it is apparent that many of them were attracted to the cultivated land and migrated from adjoining areas in search of more desirable food. This assumption is strengthened by reference to Fig. 40 which shows that the greatest number of cutworms per row were taken from

long Row E and short Row 1 both of which bordered on the grassland from which the cutworms would be expected to migrate. Also that the number of cutworms from the 10 traps nearest the E-1 corner indicated in Fig. 40 by a dotted line, exceeded the average by 332 and that those from 9 of the 10 traps nearest the A-10 corner, also indicated by a dotted line, numbered 230 less than the average, the exception being trap A-9 with 151.

When the success of chickweed sods as cutworm traps became apparent, a screen trap was devised which facilitated the examination of the traps and increased the probable accuracy of the records. This trap was 15 inches square and made from 1¼ inch lattice with a 14-mesh copper wire screen bottom. When set in the field, the top was even with the surface of the soil. Two or three handfuls of earth were thrown in the bottom and corners and a chickweed sod placed in the center. When examining these traps the chickweed was quickly shaken and the loose soil sifted through the screen bottom, leaving the cutworms and larger particles of dirt in the trap.

In order to compare the screen traps with the chickweed sods, five traps of each type were run side by side from May 5 to May 17, being examined 5 times. From the screen traps 72 cutworms were collected and 64 from the chickweed sods.

On May 18, the screen traps were moved to an asparagus field which was quite weedy. The weeds were cleared from 3 rows (about 16 feet) and 10 traps placed in the center row about 15 feet apart. These traps were examined 20 times at 3-day intervals between May 20 and July 17 and 940 cutworms were collected from them. This gives an average of 94 cutworms per trap as compared to an average of 98.7 from the chickweed sods in the larger field during the same period. In both of these collections the screen traps were practically as effective as the chickweed sods for collecting cutworms.

At the time of collection in the field the cutworms were separated into four groups from which the species were determined later by a study of of the reared moths.

Group 1 included those cutworms which became full grown early in the spring and whose external appearance is distinguished by a brown ground color with prominent wedge-shaped black markings along the back and sides. This brief general description applied to both *Agrotis unicolor* Walk., the W-marked cutworm and *Agrotis c-nigrum* L., the Spotted Cutworm, but of the 65 individuals which were reared to the adult stage only one proved to be *A. c-nigrum*. The cutworms in Group 1 represented 0.86% of the total number collected in the traps

and were active while the night temperatures were still close to freezing while the majority of them pupated early in May.

Group 2 which represented 1.62% of the total included but one species, *Agrotis fennica* Tausch., the Black Army Cutworm. This species was most numerous from May 1 to May 10 but continued to be present in small numbers until early June. It was the most injurious cutworm to asparagus even when present in smaller numbers than the species in Group 3.

In Group 3 which contained the largest number of individuals and represented 94.34% of the total number were placed the common type of garden cutworm in this section. Their external appearance is characterized in general by a light gray ground color with darker rather indistinct transverse lines on the back, having many brown freckles on the head and prominent black spiracles. Larvae ranging from recently-hatched (about ¼ inch long) to nearly full-grown (about 1¼ inch long) were found in the traps throughout the collections. Some of the larvae of this group were reared to the imago and it was then found that three species were included. These have been determined as *Euxoa ochrogaster* Guen., the Red Backed Cutworm; *Euxoa tessellata* Harr., the Common Striped Cutworm; and *Euxoa perpolita* Morr. The larvae in this group were active through May and June reaching their greatest abundance, 1021 individuals, on May 30 when many of the garden vegetables are most susceptible to their attack.

In Group 4 are placed those species which were not recognized and those which were present in very small numbers. It is possible that some of those included in this group were the same species as listed in Groups 1, 2, and 3, especially Group 3, but if so they were not sufficiently numerous to influence the records. In addition to those named above, the following species were reared from larvae collected in the traps:

Feltia subgothica Haw.—Dingy Cutworm
Noctua smithii Snell.—
Polia (Mamestra) renigera Steph.—Bristly Cutworm
Sidemia (Hadena) devastator Brace—Glassy Cutworm
Noctua bicarnea Guen.—
Lycophotia margaritosa var. *saucia* Hüb.—Variegated Cutworm

The moths were determined by comparison with those in the collection at the Boston Museum of Natural History and with the assistance of Dr. C. W. Johnson, curator at this Museum.

The seasonal abundance of each group as indicated by the collections in the larger trap experiment is shown diagrammatically in Fig 41.

During these studies it was apparent that cutworms were more active when the soil was dry and the night temperature moderately high. The season of 1927 with its frequent rains offered an excellent chance to test this point.

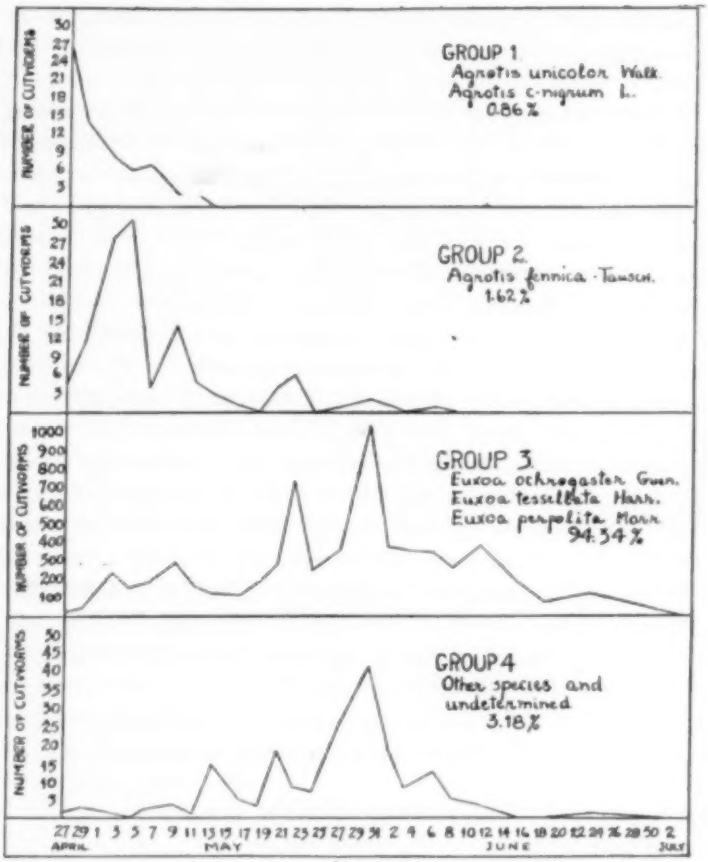

FIG. 41.—Period of activity and relative abundance of cutworm groups collected in traps at Waltham, Mass., 1927.

In Fig. 42 the collection record of the larvae in Group 3 is shown graphically together with the daily precipitation in tenths of an inch as recorded at the U. S. Weather Bureau station at Boston (10 miles east), and the average temperature between 6.00 P. M. and 6.00 A. M. as calculated from thermographic records obtained at Waltham. Between April 27 and July 1, 5.46 inches of rain fell and there were only 21 clear

days. A study of Fig. 42 shows that at least 2 days of dry weather preceded the greatest increase in the number of larvae, e. g., May 9, 22, 30 and June 11 and that following a rainfall of two-tenths of an inch or more, the number of cutworms collected decreased or remained about equal to the previous collection. It appears, therefore, that cutworm migration and activity is retarded by wet weather. The temperature graph shows rising temperatures preceding the largest collections, but

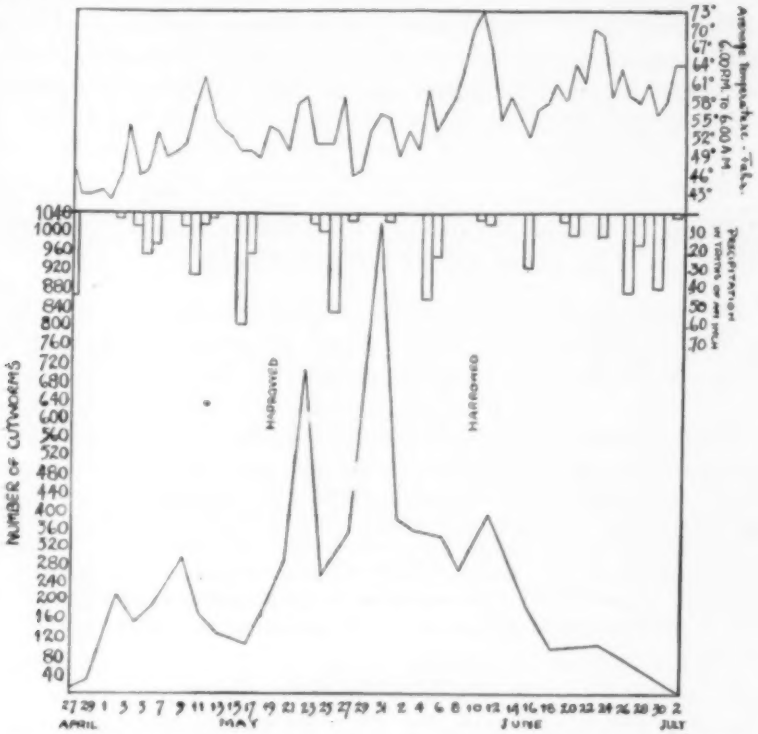

FIG. 42.—Diagram showing the relation of precipitation and temperature to the numbers of cutworms of group 3 collected in traps at Waltham, Mass. 1927.

other rising temperatures failed to increase the collections greatly and it is evident that temperature fluctuations have little influence in this respect except as they tend to reflect the precipitation record.

In order to keep down weeds, the field was harrowed on May 18 and June 9. This reduced the food supply of the cutworms and the number which were attracted to the chickweed baits following the cultivation increased in each instance.

Although cutworms are primarily negatively phototropic, larvae were frequently found on bright days lying unprotected in the loose soil apparently taking a sun bath.

The results of these studies indicate that cutworm traps may be used advantageously by entomologists to secure larvae for study or exhibition; to determine the time and degree of seasonal abundance of different species of cutworms in various localities; and to determine when to recommend the application of control measures. Gardeners will find them useful to determine if cutworms are sufficiently abundant before crops are susceptible to attack to warrant applications of control measures, and to reduce infestations by trapping cutworms along the outer borders of a garden.

STUDIES IN BREEDING INSECTS THROUGHOUT THE YEAR FOR INSECTICIDE TESTS

I. House Flies (*Musca domestica*)

By A. G. Grady, *Entomologist, Research Laboratories, The Rohm and Haas Co., Inc., Bristol, Pa.*

Abstract

A method for year around rearing of the large numbers of flies (*M. domestica*) required for insecticide tests has been developed. The equipment consists of an inexpensive insectary, breeding cages, rearing jars and stock cages. The technique of breeding, rearing, feeding and handling large numbers of larvae and adults has been made very simple and convenient. As a result of the procedure described, large cultures of flies of high vitality can be developed as easily in winter as in summer. Flies reared as described reach maturity sooner and have a shorter adult life span.

Introduction

An extensive study upon the effect of insecticidal compounds on house flies was interrupted during the winter of 1926–1927 when the progeny died in the larval and pupal stages about the first week in January. Accordingly, attention was turned to a search for a method by which flies could be reared in large numbers readily and dependably throughout the winter season. This paper details the results of a successful method evolved whereby large numbers of flies can be reared through the whole year. As the technic employed is very simple, inexpensive and dependable it may prove of value to entomologists who require large numbers of house flies for biological experiments throughout the year. Full credit for the continuous breeding of this insect

should be given to Glaser[1] who conceived the idea of supplementing the larval medium with yeast cells suspended in water during the winter months.

The literature on the biology of *Musca domestica* has assumed extensive proportions and it is not the intention of the writer to deal with it except to note some observations on the activity and longevity of the imagines during the winter months.

The larvae were reared throughout the winter on a medium consisting of fresh horse manure which was kept in a moist condition with water and yeast cells suspended in water, according to Glaser's method. Excellent results were obtained. Attempts were made during the latter half of January and during the month of February to rear flies on horse manure alone. In every case, except two, the insects died either in the larval or pupal stages. In the two successful attempts the horse manure was taken from the stables during a warm spell. Whether this had anything to do with carrying the larvae through to the adult stage was not determined.

From these experiences and the experiences of other investigators it was concluded that unless the horse manure was supplemented during the winter months larval life could not be supported and a continuous supply of insects could not be maintained.

The adult insects thrived exceedingly well on a diet consisting of milk, lump sugar, sweetened bread and yeast suspended in water. About 10 cc. of milk was dropped into the cages every day and about the same amount of yeast suspension was fed every second day. Fresh sweetened bread was placed in the cages about once a week. The bread was kept in an assimilable condition by wetting it with water. Other foods were added to this diet at different times such as beef extract, casein and fish-scrap. However, the adults developed sufficiently well on milk, bread, sugar and yeast so that the strictly protein foods were not used as regular parts of the diet.

The apparatus and equipment used to rear the house flies throughout the winter months were as follows: An insectary where the breeding cages, rearing jars and stock cages were kept; breeding cages in which the insects were bred and oviposition took place; rearing jars in which the insect was reared from the egg to the adult stage; and finally, stock cages where the flies used for insecticidal tests were kept.

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[1]Note on the continuous Breeding of Musca domestica. Journ. Econ. Ent., 1927, XX, 432–433.

Insectary

A chamber 8½ feet long, 4 feet wide and 8 feet high was built in a laboratory attic. A window was provided at one end which admitted sufficient light to carry on the work. Entrance was obtained by a small door at the opposite end of the chamber. All cracks where the woodwork joined the floor and ceiling and around the door and window were covered with weather stripping to prevent drafts. Shelves, 1 foot wide, were built along the sides of the chamber to hold cages and rearing jars. The heating element which consisted of a well trapped steam coil was placed underneath the window. A fairly constant temperature was maintained with a Sarco heat regulator. This regulator was set at 30° C., (86° F.). Any variations of temperature were recorded on a maximum and minimum thermometer which was placed next to the thermostat. In this manner the temperature stayed within two or there degrees. A simple humidifier consisting of a trough 35 inches long,12 inches wide and 6 inches deep, filled with sawdust was placed under the steam coil. The sawdust was wetted down at intervals to keep the relative humidity at about 40%. A wet and dry bulb thermometer was used to check the humidity of the chamber.

Breeding Cages

Because flies are susceptible to nutritional deficiency diseases and to attacks of parasites and parasitic fungi it was found best to keep the insects used for breeding purposes in relatively small separate cages so that if one colony of breeders became infected the disease could be checked before it spread to the other cages. As a result of this precaution, no high mortality occurred among the flies in the breeding cages that could be laid to a diseased condition.

As it was desired to have on hand hundreds of flies of known ages at all times, six breeding cages were used. Their dimensions were: length, 18 inches; breadth, 9 inches; height, 10 inches. The floor was made of a board ½ inch thick to which the frame was attached. The frame was constructed of ½ inch strips. The upright strips were nailed to the floor of the cage and connected by ½ inch crosspieces. The sides, top and back were made of wire fly screening, (1/16 inch mesh) tacked to the frame. The front was a piece of glass set in grooves which served as a door. These cages are easy to clean, provide plenty of room for the insects to move about and access to the inside is gained easily by pushing up the glass door to introduce food and insects.

Rearing Jars

Ordinary battery jars 6 inches in diameter by 8 inches high were used for rearing the larvae. The top of the rearing jar consisted of a piece of cheese cloth about 8 inches in diameter with a hole about ¾ inches in diameter in the center. This hole was reinforced by heavy paper washers about 1½ inches in diameter glued to both sides of the cheese cloth. A cork plug was inserted in the exit hole. The top was held in place by a ¾ inch elastic band. This type of top is inexpensive, easily made and will serve for a number of generations of flies.

Stock Cages

As flies were not used for insecticidal tests after they were five days old only five cages were necessary. These cages were boxes of ½ inch lumber, 24 inches long, 12 inches broad and 10 inches high. One side was fitted with a hinged wooden door 3 inches by 3 inches to admit flies and introduce food. The top of the cage was made of wire screening (1/16 inch mesh). In the center of the wire top a hole about ½ inch in diameter, for the removal of flies, was made and a cork inserted.

Procedure

In each of the six breeding cages about two hundred adult flies, about equally divided as to sex, were kept. When the insects died or became unduly soiled or injured they were replaced by others. A 200 cc. beaker filled with wet horse manure was placed in each cage for the flies to oviposit on. In the course of two days hundreds of eggs were deposited on the medium, about half of which had hatched. Every other day the beakers containing eggs and larvae were removed. Other beakers filled with fresh horse manure, to which about 15 cc. of water had been added, were then placed in the breeding cages. In this way fresh medium was kept in the breeding cages continually for the flies to oviposit on. It appears that this part of the technic stimulated the responses of the females in regard to oviposition and aided somewhat in keeping the flies from laying eggs on the adult food, i.e., the sweetened bread.

To insure a large supply of adults, four cultures were started every other day. About five or six hundred eggs and larvae, obtained as above, were transferred to each of the four rearing jars. Each jar was filled to about the three-fourths mark with fresh, loosely packed horse manure. It was found that if about 200 cc. of water was added to the manure when the culture was started it was sufficient to keep the

medium in a moist condition until the adults emerged. The losses resulting from larvae drowning were insignificant. To this 75 cc. of the supplementary food, yeast cells suspended in water, was added and about 10 cc. more was dropped in the jars every other day until the larvae were about ready to pupate. The amount of yeast to be fed varies, of course, with the number of larvae to be reared. It was found that in this case if the amount of yeast suspension was cut down the adults, if they emerged, were apt to be stunted and possess little vitality. In making up the yeast suspension Glaser[1] advises, "In practice we dissolve a one pound bakery cake of commercial yeast in two liters of water. The suspension of yeast cells is then distributed in pint bottles and autoclaved, to kill fungi which often cause trouble, and stored on ice." We have found that if one pound of yeast is dissolved in two and one half or three liters of water, very good results can be obtained. At first the yeast suspension was autoclaved using pint milk bottles as receptacles. A pyrex flask was later substituted for the milk bottles as these are apt to crack when subjected to high temperatures a few times. A number of cultures were reared using yeast suspension which was not autoclaved. While this part of the technic may be left out, with little or no difference in the results, it is advisable to sterilize the yeast suspension if an autoclave is available. The horse manure containing eggs and larvae was then emptied onto the fresh medium, the covers fitted on the jars and the culture was incubated at 30° C. The larval medium settled in a few days to about the middle of the jar which gave the adults plenty of room to move about when they emerged.

At this temperature the time required from egg to adult was approximately eleven days. As the eggs were deposited over a period of two days in the breeding cages some of the adults emerged nine days after being placed in the rearing jars and the rest within eleven days, other conditions remaining equal. As the flies emerged they were taken out of the jar in the following manner: The cork plug was removed from the top of the rearing jar and a wide mouthed bottle placed over the exit hole. The jar was then darkened, except around the exit hole, with a cloth cover. As house flies are positively phototropic, most of them will come out into the bottle in a few minutes. The flies were then either placed in a stock cage to be held for insecticidal tests or used for breeding purposes. It is advisable to take the flies out of the rearing jars soon after they emerge so as to avoid overcrowding. When large numbers of adults are allowed to stay in the rearing jars they are apt to become excited and mill about the top of the jars in an effort to escape. This often results in a high mortality.

To draw any conclusions from insecticidal tests which would shed light on the toxicity of a compound the age and the condition of the insects used should be known. This appears to be particularly true of flies. We have found that the adult house fly bred under artificial conditions during the winter months is most active and resistant when it is four or five days old. In comparing results of insecticidal tests run during the summer with wild flies and those reared artificially it developed that winter flies, four or five days old, were more uniformly resistant to toxic compounds than wild summer flies and fully as resistant as controlled cultures developed during the summer. As the age of the flies was of great importance they were kept in separate cages dependent on the date they emerged.

After the fifth day flies which had not been used for insecticidal tests or transferred to the breeding cages were killed. The cage was then thoroughly washed with soap and water and dried. As the adults were continually emerging in the rearing jars it was necessary to use the cage immediately for a new supply. In this way a continuous cycle was maintained with a minimum number of cages.

When flies were needed for insecticidal tests they were removed by the bottle method described above. The approximate number desired were collected in a few moments. As a matter of precaution it is advisable to darken the cage gradually as the flies are easily excited and may injure themselves mechanically if suddenly aroused.

Observations

A few observations on the activity and longevity of the adults during the winter months were made. It was found that the adult fly was very active and resistant until about the eighth day after it emerged, reaching what might be called its peak of activity and resistance about the fifth day. The longevity of the adult varied from two to thirty-three days with an arithmetical mean of thirteen plus days. It was also noted that the ovaries and testes developed rapidly and in some cases eggs were deposited by the flies in a little over three days after the time of emergence. Some investigators[2] have reported that the life of the adult house fly, reared during the warmer seasons, averages approximately twenty days and that the time required for the development of the ovaries and testes was longer by several days than observed in this case. Whether this comparatively short life cycle and rapid

[2]Howard, House Flies, U. S. Dept. Agri. Farmers Bulletin, 679, 1915; Glaser, Rearing Flies for Exp. Purposes with Biological Notes, J. Econ. Ent., 1924, XVII, 486–496.

development was due to the fact that the flies were continually subjected to a constant temperature of 30° C., a special diet, absence of direct sunlight, or to other factors was not determined.

During the spring, summer and early fall the flies were reared in a part of a greenhouse which had been partitioned off. The same technic was employed as described in the preceding pages except that the supplementary food was not fed to the larvae. The cultures were transferred to the winter insectary toward the latter part of October. Of course, the time of transfer will depend on climatic conditions.

The writer takes this opportunity to express his indebtedness to Dr. W. S. Abbott of the Bureau of Entomology and to Dr. R. W. Glaser of the Rockefeller Institute for Medical Research for the valuable suggestions embodied in his papers and for his personal assistance.

Summary

A convenient insectary and cages and simple methods are described for breeding large numbers of house flies during the winter. A few observations on the activity and longevity of the adults are noted.

STUDIES IN BREEDING INSECTS THROUGHOUT THE YEAR FOR INSECTICIDE TESTS

II. Leather Beetles (*Dermestes vulpinus* Fab.)

By A. G. Grady, *Entomologist, Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

The leather beetle (*D. vulpinus* Fab.) has been used with very good results for certain kinds of insecticidal experiments. This insect can be reared simply and dependably in large numbers throughout the year. Compared to some insects it is very resistant to certain toxic compounds and serves very well in measuring their insecticidal efficiency.

Introduction

The value of having on hand an adequate supply of suitable insects for insecticidal experiments throughout the year instead of during their natural occurrence is, of course, fully realized. It is not only desirable to obtain and rear, throughout the year, insects that are prolific, can be easily handled and have comparatively short life cycles, but it is also of importance that these particular animals should be as resistant, or more so, to toxic compounds as insects found in the household and those of economic importance to agriculture.

A search was made for an insect that would meet the above requirements and after considerable investigation it was decided that the leather beetle (*Dermestes vulpinus* Fab.) would serve very well as a standard insect for biological experiments.

This paper gives a short description of the biology of *D. vulpinus*, the technic employed in rearing large numbers throughout the year and its value as an experimental insect for biological tests.

Biology

As *Dermestes vulpinus* is of comparatively little economic importance very little reference is made to its biology in the literature. Riley in one of his reports[1] gives an account of this insect as a destroyer of leather goods and Illingworth[2] has made a complete study of its biology and has written on its destructive habits as a pest to the fishing industry in Hawaii. It was necessary, of course, to make a complete study of this insect if it was to be used as a standard insect for insecticidal tests. The following notes on the biology of *Dermestes vulpinus* were made during the winter at a temperature of about 23° C. and the relative humidity at about 40%. A short description is also given.

The time required from egg to adult at the above temperature was about fifty-five days. The eggs, which are about 2 mm. in length, of a creamy-white color and cylindrical in shape, hatch in three or four days. The larvae upon hatching are about 2 mm. long, attaining a length of about 12 mm. before pupating. The dorsal surface is covered with a complex clothing of hairs and is of a dirty brown color. The larvae are very active and are voracious eaters. The number of times the larvae moult varies but in the course of their development, the average is seven. We have observed some larvae shed their skins ten or eleven times during their development, presumably because of a scarcity of suitable food. In all about forty-four days are spent in the larval stage. When the larvae are about to pupate the larval skin splits down the back and remains as a pupal covering. On the last larval skin a number of spines occur serving as a protection for the pupa. The larvae are negatively phototropic and are generally found in dark places. Illingworth[2] observed that the larvae are fully developed after the sixth moult and that the complete larval period for the seven instars was found to

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[1]Riley, C. V. "The Leather Beetle or Toothed Dermestes." Rept. Comm. Agric. U. S. 258–264, 1885.

[2]Illingworth, J. F. "The Leather Beetle (*Dermestes vulpinus* Fab.), a Troublesome pest of Dried Fish in Hawaii." Proc. Haw. Ent. Soc. III, No. 5, April, 1918.

require fifty days, while the life cycle, from egg to adult, was passed in sixty-four days, which is somewhat longer than we have observed.

The pupal stage lasts seven or eight days. After the imago emerges it passes through a preoviposition period of about ten days. The adult beetle is from 8 to 12 mm. in length and rather slender, the male being smaller than the female. The antennae are short, terminating in a large club and on the underside of the thorax is the characteristic hollow for their reception. The elytra and dorsal surfaces of the pro-thorax and head are black specked with gray. The margins of the thorax are covered with grayish scales. The ventral surface is of a silvery-white color with a series of lateral spots which appear to be bluish-black because of the absence of scales. The adult is a weak flier seldom making use of its wings and then only for short flights. It is very quick on its feet and will run rapidly to cover if disturbed. However, it is much easier to handle in this respect than a cockroach. The adult beetle has a life span of four or five months or more and reproduces over a period of two months at least. According to Illingworth[2] "Beetles that emerged Jan. 2, 1917 are still alive and actively reproducing April 5th, 1917."

Rearing Technic Employed

The methods employed in rearing large numbers of these insects are very simple and quite inexpensive. After a culture has been started little or no attention need be paid to it, except for the addition of food, until the adults emerge.

At first the insects were reared in a large wire cage. This cage was 6 feet by 6 feet by 6 feet with a frame of 2 by 2 inch lumber to which ordinary fly screening was tacked. This cage served very well during the winter and thousands of insects were reared in it. However, about the middle of the following summer the larvae were attacked by parasites and the whole culture was killed in a very short time. Tin cans were then substituted for the above cage and the culture reared in separate units. These containers were 10 inches in diameter by 8 inches high and were equipped with tight fitting covers. Holes were punched in the centers of the covers to admit air and keep down the humidity. Very good results were obtained with this type of rearing container. By rearing the insects in separate chambers little trouble was experienced from parasites or diseases because if the larvae in one unit became infected this condition could be easily checked before spreading throughout the rest of the culture.

As the adults and larvae require foods high in protein content a diet consisting of fish-scrap, salmon, cheese and bacon was fed. A layer of

oily fish-scrap about ½ inch deep was spread over the bottom of the rearing chamber and served both as a food and as a carpet for the larvae to move about. The other foods were added as needed, i.e., salmon was fed to the larvae at first and when that had been consumed, cheese was added and so on in an effort to give some variety to the diet. The foods were not allowed to dry out, being kept in a fairly moist condition by adding water when it was needed. The cultures thrived exceedingly well on this type of diet. In fact, a very low mortality was obtained in breeding these insects with the exception of a few isolated instances when the larvae were attacked by parasites.

In starting a culture about thirty adult insects, equally divided as to sex, were placed in a container to which food had been added. Over a period of ten days about 150 to 200 eggs were oviposited. As this was about the maximum number reared in each container, the adults were taken out after this period and either used for further breeding purposes or for insecticidal tests. With the exception of feeding the larvae little attention was paid to the culture. The containers were cleaned out about once a month. This was accomplished by sifting out the fish-scrap with a No. 10 mesh sieve, the larvae, of course, were too large to get through the mesh. The tin cans were then thoroughly cleaned and a fresh layer of fish-scrap and other food added. The larvae were then put back into the containers and were not disturbed, except when food was added, until the adults emerged. In practice we started about three cultures a week which assured us of an ample supply of adults at all times. The adult insects were kept in separate containers with the exception of those used for breeders in starting new cultures.

Value of *D. vulpinus* as an Insect for Biological Experiments

While the ease with which large numbers of these insects could be reared throughout the year was of importance, their greatest value lay in the fact that they were very resistant to toxic compounds and that variations generally met with in check and control experiments were for the most part negligible.

During the summer of 1926 a number of tests were made to determine the relative resistance of Dermestes vulpinus and other insects to compounds of known toxicity. Among the insects used were the common cockroach (*Blatella germanica* L.), the Japanese beetle (*Popillia japonica* Newn.), the Colorado potato beetle, (*Leptinotarsa decemlineata* Say), and the cockroach (*Periplaneta americana* L.). This series of experiments was made under the same conditions using direct contact sprays.

It was found after considerable study that *Dermestes vulpinus* was much more resistant to different contact sprays than the other insects used. It was also found that high mortalities which are often encountered in check and control cages while working with other insects was almost negligible with *Dermestes vulpinus*.

This insect also proved of value in determining the toxic value of compounds which were not readily dissolved in water or were poor emulsifiers. If such a compound could be dissolved in a volatile carrier such as petroleum ether its toxic valuation could be determined by spraying it on *Dermestes vulpinus*. Petroleum ether alone would cause a high mortality among some insects if they were thoroughly sprayed with it. However, in this case a mortality of about twenty per cent was obtained with the carrier alone with almost mathematical precision.

The adults and larvae were also used and found to be quite satisfactory in fumigation experiments. They were used along with the flour beetles (*Tribolium confusum* Fab.), the Indian meal moth (*Plodia interpunctella* Hbn.), the rice weevil (*Calandra oryzae* L.), the common bean weevil (*Bruchus obtectus* Say) and the pea weevil (*Bruchus pisorum* L.) and were found to be equally as resistant.

STUDIES IN BREEDING INSECTS THROUGHOUT THE YEAR FOR INSECTICIDE TESTS

III. Roaches, Clothes Moth, Weevils

By A. G. Grady, *Entomologist, Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

(A) Roaches (*Blattella germanica L.*) can be conveniently reared in large numbers by using a simple rearing cage which is described. The technique employed in rearing these insects is given.

(B) The webbing clothes moths (*Tineola biselliella* Hummel) have been reared very easily in small containers housed in an insectary. The methods used in rearing large numbers of clothes moths is described.

(C) The common bean weevil (*Bruchus obtectus* Say), the rice weevil (*Sitophilus oryza* L.), and the confused flour beetle (*Tribolium confusum* Fab.) were reared in large tin drums kept in an insectary. The simple procedures employed in rearing these insects are given.

In studying the effect of various toxic compounds it was necessary to test them against many different insects in order to ascertain their value. For instance, a compound may be of little value when used as

an "air-float" or as a direct contact spray but it may prove to be highly toxic when used as a fumigant. To insure a varied and plentiful supply of insects for biological experiments a study of breeding procedure was made and positive methods for the year around propagation of the following insects were developed: The house fly (*Musca domestica* L.), the leather beetle (*Dermestes vulpinus* Fab.), described in preceding papers, the Croton bug or german cockroach (*Blatella germanica* L.), the webbing clothes moth (*Tineola biselliella* Hummel), the common bean weevil (*Bruchus obtectus* Say), the pea weevil (*Bruchus pisorum* L.), the rice weevil (*Sitophilus oryza* L.), and the flour beetle (*Tribolium confusum* Fab.).

Little difficulty was experienced in rearing large numbers of these insects by the technique evolved and the testing of different compounds as contact sprays, fumigants, etc., was never held up because of a lack of suitable insects. As these insects are quite common and in some cases of great economic importance, their biology is too well known to warrant a description here.

(A) The Croton Bug (*B. germanica* L.)

To rear large numbers of cockroaches presents a difficult problem in that they are a hard insect to confine to any one place. Because of their migratory habits and their ability to escape through the smallest

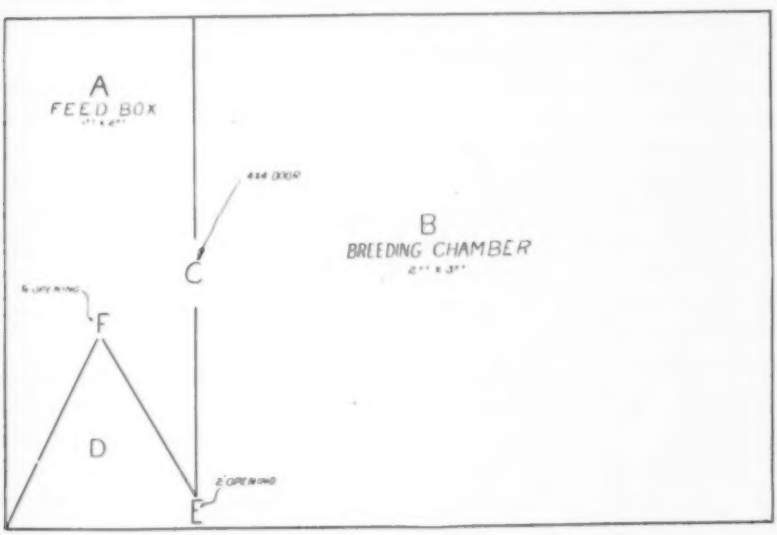

Fig. 43.—Plan view of breeding chamber for cockroaches.

cracks and crevices, unless a specially constructed cage is employed, these roaches will overrun an insectary and become a general nuisance in a very short time.

In an effort to keep these insects segregated, a rearing chamber (Fig. 43) 2 feet high by 4 feet long by 2 feet wide was constructed of matched lumber. This cage was made as tight as possible by caulking up all cracks and joints. The inside of the cage was partitioned off so that one-quarter (A) of it was used as a feed box and the other section (B), which was filled with loosely piled lath, served as a runway and breeding place for the insects. A small opening (C), about four inches square, was provided at the bottom of the partition which could be closed tightly by means of a sliding metal sheet. When open this gave the roaches easy access to both compartments. A V-shaped section (D) was built of ½ inch boards inside the feed box. This section had a two inch opening (E) leading from the large compartment and a very small opening or slit (F) at the junction of the two boards comprising the V. The insects could enter through the opening (E) into the V-shaped section (D) from the large compartment (B) and easily gain access to the feed box (A) through the small opening (F) at the junction of the two boards. However, once they got into the feed box it was difficult for them to find their way back to the large compartment provided that the entrance (C) in the other partition was closed. In this way, the roaches were easily caught when needed for insecticidal experiments. A door, 1 foot by 1 foot, was provided on the top of the feed box. This door was equipped with a felt strip, somewhat on the order of weather stripping, which served as an insect tight gasket. The construction of this type of cage was suggested by Dr. W. S. Abbott of the Bureau of Entomology.

A galvanized iron tray, 5 feet long by 3 feet wide, by 6 inches deep was made and filled with water to which some kerosene had been added. The rearing cage was then set on bricks in the tray, resting just above the water line. This arrangement provided a sort of moat which served very well to keep the insects that succeeded in escaping from the inside of the cage from getting into the insectary proper.

The roaches were fed sweetened bread and milk once a week and occasionally about 100 grams of yeast was added to the usual food supply. The inside of the cage was kept in a damp condition by wetting the section in which the lath was placed.

At a temperature of about 25° C., *B. germanica* will develop from the egg to the adult stage in about five and one-half months. As each capsule oviposited by the females contains about forty eggs, a very

large culture can be reared in a surprisingly short time. We have reared many hundreds of these insects by the above method with excellent results. Losses of cultures through disease and attacks by parasites, which are often encountered in rearing other insects, were not experienced with roaches.

(B) The Clothes Moth (*Tineola biselliella* Hummel)

The webbing clothes moth (*Tinzola biselliella* Hummel) was reared in large numbers and used extensively in fumigation experiments. Because the clothes moth is subject to attacks by mites and other parasites, the cultures were reared in separate units. Tin cans 10 inches in diameter by 8 inches high were used as chambers in rearing these insects with excellent results. These containers were provided with tight fitting covers in which small holes were punched.

The larvae were raised on a diet consisting of feathers and wool and a number of cultures were reared on dried squirrel skins. A culture of between 75 to 100 eggs and newly hatched larvae was introduced into each container. No attention was paid to the culture other than to watch that it remained free of parasites and that an adequate supply of food was on hand until the larvae had developed sufficiently to be used for fumigation experiments. Of course, a number of the larvae were allowed to develop to the adult stage so as to insure a sufficient supply of eggs and larvae for future cultures. In working with the webbing clothes moth, we have observed that, at a temperature of about 25° C., it develops from the egg to the adult stage in a little over three months.

(C) Weevils

The common bean weevil (*B. obtectus* Say), the pea weevil (*B. pisorum* L.), the rice weevil (*Calandra oryzae* L.) and the confused beetle (*Tribolium confusum* Fab.), were reared in containers in a greenhouse.

The common bean weevil was reared in great numbers in twenty-five gallon tin drums. These were provided with tight fitting covers in which holes had been punched and served very well as rearing chambers. About one-third of a bushel of infested beans was placed in each container. About every three or four months new food was added and the remains of the old beans sifted out. These cultures were reared in the outside insectary above described throughout the year. During the winter a temperature of about 18° C. was maintained in the greenhouse. Of course, the temperature inside the drums was much higher, a temperature as high as 35° C. having been recorded because of the heating of infested media.

The same technique was employed in rearing the pea and rice weevil and the flour weevil, except that peas were placed in the drums where the pea weevils were reared and corn on the cob was used as a food for the rice weevils. The confused beetles were reared on ground bran. All of these weevils were used in studying the toxicity of various compounds when used as fumigants.

STUDIES IN INSECTICIDAL ACTIVITY

I. Testing Insecticides Against Flies

By C. H. Peet and A. G. Grady, *Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

An attempt has been made to establish the testing of household insecticides on a sound and comparable basis.

The necessity for the reduction of variables to a minimum is pointed out and it is suggested that a definite standard be adopted for time, temperature, humidity, insecticide concentration, spray concentration, pressure in sprayer, air condition, angle of spray, kind of insect, and condition of insect.

Emphasis is placed upon the fact that many tests and extended observations are necessary and explicit directions for conducting tests upon flies are given.

Although a vast amount of work has been done on examining various compounds to determine their value as insecticides, the variations in the methods of testing these compounds and in the standards set up by the various investigators have made it almost impossible to draw valid comparisons between the results reported. In some cases insects have been tested by exposing them to the fumes of the particular compound being tested even though the compounds were relatively non-volatile and had to be heated in order to volatilize them. In others the compound being studied was dissolved in some oil carrier and dispersed by spraying. Still other determinations of insecticidal effectiveness have been made by completely immersing the insect to be tested in the material under consideration either at 100% concentration or at various dilutions. Obviously there is almost no common ground between these methods of testing. The desirability, however, of formulating some uniform testing procedure is evident and it is hoped that this series of papers will serve to stimulate other investigators to work upon this problem and to offer such alterations and improvements in technique as may seem desirable in order that insecticidal tests may be made suffi-

ciently simple to be carried out in any reasonably adequate laboratory and sufficiently uniform to be quite strictly comparable wherever they may have been performed.

The most common pest the world over is the fly and the economic significance of the various species of stable flies is so well appreciated that a large program of research upon its control is being undertaken by the government. The annoyances caused by the house fly as well as the danger of infection due to its presence are pointed out in the advertisements of every magazine. The smaller and generally less prevalent fruit flies, gnats, etc., constitute a special problem in certain localities. Accordingly this first paper deals specifically with methods of determining the effectiveness of compounds against flies. There is, of course, a great variation in the resistance of the different families of flies to the action of insecticides, but the relative resistance of these various families follows approximately the same curve against all insecticidal compounds. Accordingly, once that curve has been established for all the families, which are sufficiently common to constitute pests, it is only necessary, in testing a new compound, to test it against one or two families in order to locate the curve of its efficiency. This paper makes no attempt to establish these curves but serves solely to point out a method of testing which is applicable to all families of flies and which can be followed by other investigators.

The determination of toxicity against insects must be a purely biological test and, like all biological tests, it is subject to the very considerable variability which accompanies the reaction of the living organism to external effects and influences. This variability is innate in all creatures and cannot be controlled but the superficial variables which have heretofore been ignored, or too little considered, can be so accurately controlled that only the biological variable remains to remove such tests from strict reproducibility and the average will be just as certain as life insurance mortality tables.

The variables which this investigation has shown to possess the greatest significance are: time, temperature, humidity, insecticide concentration, carrier, fineness of spray, air conditions, angle of spray and condition of insect.

It is obvious that it is unfair to draw a comparison between two insecticidal compounds one of which is allowed to work upon the insect for twice as long a time as the other.

The importance of temperature control may easily be demonstrated by exposing two groups of insects from the same brood to the same insecticide at say 60° F. and 85° F. The higher percentage kill among the insects in the warmer chamber will be quickly appreciated.

The influence of humidity on the resistance of the insect to toxic compounds has been too generally ignored in testing for insecticidal power. It does not have as great an effect as the temperature differential but it does exert sufficient influence to alter the results obtained with the same material in successive tests.

The fact that a higher concentration of material being tested in any given solution should produce a greater or more rapid kill does not require discussion.

The variations in effectiveness produced by variations in spray concentration are less easily demonstrable but undoubtedly just as certain for if the spray or vapor of any material under consideration be more attenuated in one instance than in another, there must be a higher concentration of insecticide in the area which has the greatest spray concentration.

Few carriers are inert but many studies have shown that there is a very considerable difference between the toxicity of these numerous relatively inert solvents.[1] Accordingly, if one investigator reports on an insecticide using as a carrier a certain fraction of Pennsylvania Oil, another on the same material using a corresponding fraction of California Oil, there will be a disagreement. Similarly, if one investigator uses a certain fraction of Pennsylvania Oil and another a different fraction of the same oil, they will obtain different results.

Griffiin, Richardson and Burdette[2] have shown that the size droplet produced by a sprayer has a very marked effect upon the insecticidal activity of the same material. Droplets of 5 to 10 mu produce about the maximum effect whereas droplets of 2 mu and smaller decrease the activity of the insecticide. These conclusions were based upon a study of contact sprays and insofar as the insecticide serves as a contact poison, they will apply to it. If, on the other hand, the insecticide functions in the vapor phase, the rate of evaporation will increase as the droplet size decreases and the reverse conclusion must be drawn. There are two ways of producing these variations in droplet size. One is by changing the type of atomizer or spray and the other by changing the pressure on the same sprayer. Since it is probable that the majority of tests will be made using the same sprayer, the variable which must be controlled is pressure.

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[1]Moore & Graham. A Study of the Toxicity of Kerosene, Jour. Econ. Ent., 1918, XI, 70-75.

[2]Griffin, Richardson & Burdette. Relation of Size of Oil Drops to Toxicity of Petroleum-Oil Emulsions to Aphids. Jour. of Agri. Research, Vol. 34, Pages 727–738.

By air conditions is meant whether the air is fresh or exhausted and whether it is stagnant or in motion. The factor of freshness can probably be ignored because the chamber is always aired between tests but whether or not the air in a testing chamber is motionless or well agitated does have considerable effect for two reasons. First, a given compound and its carrier may have a high specific gravity thus producing a higher concentration of insecticide in the lower part, that is, along the floor of the chamber, than at the top or it may tend to concentrate at the top. The resulting effect upon flies being tested will obviously depend upon the part of the chamber in which they remained. In a sense this factor is only an extension of the spray concentration factor.

The importance of the angle of the spray is also closely related to spray concentration. If the spray enters the chamber from all directions there is much more uniform dispersion of the material under study. Also, of course, this factor is of importance if the spray comes in contact with the insects. If the material being examined is heavy and is sprayed downward upon the fly it is possible that its wings will shield its body or perhaps it would be more correct to say that if the spray were directed upward against the fly there would be greater likelihood of its coming in contact with the more vital parts of the insect.

Condition of the insect is one of the most important factors to be considered. It requires no elaboration to point out that an old fly or a vitiated fly or a very young fly or a fly in any way enfeebled will be more susceptible to the action of any toxic material than will a strong healthy individual.

The method of testing which this paper wishes to advocate is as follows:

CHAMBER: All fly tests should be carried out under conditions which at least approximate those existing in the fly's normal environment and for this purpose a chamber of sufficient size to enable the fly to move about freely and approximately as unrestrictedly as it normally would should be provided. A very satisfactory size has been found to be a 6 x 6 x 6 foot cube. In the studies upon which this paper is based, this chamber was made of wood with the bracing members on the outside, leaving the inside as free from projections, corners, ledges, etc., as possible. The inner surfaces were originally well painted with white enamel in order to prevent absorption, by the wood, of material being tested. This paint, however, adsorbed and absorbed a certain proportion of the oily materials being studied and, although it was carefully wiped out after each test, it was impossible to remove all traces

of the preceding materials. Accordingly, the inside, including floor and ceiling, was lined with transite board, an asbestos composition, all corners were sealed with a Silex sodium silicate cement and the walls were rendered as nearly non-absorbent to oils as possible by painting with sodium silicate. In the center of the ceiling a glass window was set with a bulb above it for illumination. A tight closing door, large enough for a man to enter, was set in one wall and the adjoining walls were provided with glass windows in the center of each. These same walls each had four square ports 6 x 6 inches covered with wire gauze and provided with tight fitting hatches. Each wall had two one-half inch holes bored through it six inches from the ceiling and closed by corks. Inside the chamber, on the floor, was set an eight inch oscillating fan completely enclosed by a guard of wire gauze.

PROCEDURE: Each test was run upon a considerable number of flies, never less than 100 and usually rather more but not exceeding about one per cubic foot. These were liberated in the chamber, which was kept at 85° F., the fan was turned on and the insecticide was introduced through the one-half inch holes along the ceiling by means of a modified Rexall Kantleek Atomizer No. R-1501. The modification consisted in replacing the reservoir of the atomizer by a narrow 20 cc. cylinder made by cutting off an ordinary burette and sealing one end and in substituting a sufficiently long outlet tube to reach practically to the bottom of the cylinder for the shorter one which is standard equipment. By reading the level of the liquid before and after spraying, the amount used can be very accurately determined. This atomizer was operated at 12½ pounds pressure from a constant pressure airline controlled by a reducing valve. The amount of solution used in each test was 12 cc. and this was sprayed in about equal quantities through each top hole. The door and all ports were, of course, tightly closed during this procedure. The chamber was kept closed for ten minutes during which time observations on the flies could be made through the windows to study the manner in which the material being tested was affecting them. At the end of ten minutes the square ports were all opened and the number of flies still clinging to the walls and ceiling was counted through the side windows. The flies which had dropped were carefully gathered up and transferred to clean cages made completely of wire gauze except for the bases. It was considered that the flies still off the floor had escaped the action of the insecticide. The flies in their gauze cages were kept for twenty-four hours to observe whether there was ultimate recovery or death. At the end of this period, these insects were counted and the number still alive added to those which had been on the walls of the

chamber. As soon as the flies had been removed from the testing chamber a Buffalo Blower was turned on sweeping out the chamber by sucking air through it.

The variables thus far held in control are time, temperature, spray concentration, pressure in spray, air conditions, angle of spray, and kind of insect. The condition of the insect is more particularly dependent upon how it has been bred and this phase of the problem is discussed in a paper by Mr. A. G. Grady on the breeding of flies.

Tests conducted following this procedure show a low average variation and it is entirely reasonable to presume that any investigator could obtain very uniform results following the method.

STUDIES IN INSECTICIDAL ACTIVITY

II. Direct Contact Sprays

By C. H. Peet and A. G. Grady, *Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

A standardized method for testing contact sprays has been developed. The special test cages employed are described and the exact procedure followed is given in detail. An equation has been developed which expresses the effectiveness of the insecticide mathematically.

A special method is outlined for the testing of insecticidal powders.

The testing of insecticides which act by direct contact rather than by volatilization or by air float presents a special problem. The insecticide should be brought well in contact with the insect being tested, the viability of the insect should be definitely established, and the method of applying the insecticide should be quite strictly reproducible. The methods, which this paper advocates, involve testing the material under consideration in the form in which it would be applied in the household, namely, in oil solution and in a strictly inert carrier together with control tests to determine the normal mortality among unsprayed insects.

Insecticides of this type commonly do not have a very rapid action nor is rapidity of action required. The creatures against which they are used are generally creeping pests such as ants, roaches, millipeds, bedbugs, and various members of the coleoptera. Since it is, of course, impossible to test any given material against all the types of insect which it might destroy, the first step is the choice of a reference insect. This laboratory has found the common cockroach (*Blatella germanica*)

and the ordinary leather beetle (*Dermestes vulpinus*) easily bred under artificial conditions and possessed of sufficiently short life cycles to serve as excellent test insects.

Testing the Finished Insecticide

The test chamber employed consists of a box of wire gauze approximately 8 by 8 by 8 inches. It is made from a block of 1 inch pine to one edge of which are nailed two 1 by 1 inch uprights, 8 inches long, connected by an 8 inch crossbar. To each of the upper corners of the frame a thin oak strip, 1 inch wide, is nailed and bent in practically a quadrant until it meets the base where it is attached. Grooves cut in the upright frame permit a plate of window glass to slide up and down and the rest of the box is covered with 16 mesh wire gauze. Such a chamber makes it possible to spray the insects contained in it from practically all directions and affords them practically no covered corners in which they can hide and avoid the spray. Because insects of this type are reared with difficulty in batches of uniform age, the method of probabilities is employed and from 50 to 100 insects of the kind being tested are transferred from the large breeding cage to each test cage. Five test cages are employed for each test; two of them are lethal chambers and three are check cages. One of the checks is a starvation cage, in which from 50 to 100 insects are placed with no food; in the second, approximately the same number of insects is placed but an adequate supply of food is provided; in the third, about the same number of insects is introduced and these insects are used to test the toxicity of the carrier being employed.

Procedure: The same precautions with regard to fineness of spray, which have been emphasized in a preceding paper, (Studies in Insecticidal Activity—I. Testing Insecticides against flies,) should be observed. The spray is directed upon the insects from every possible angle until each insect has been thoroughly wet all over. This is not, however, to be interpreted to mean that the insects are to be drenched to the point of drowning. The insects in the third check cage are then sprayed in the same manner with the hydrocarbon or other carrier alone. After spraying is complete the proper food (salmon, cheese or other protein material in the case of the dermestidae and bread and milk in the case of cockroaches) is put in each cage on a flat dish in order that the food may not absorb insecticide. For comparisons among the cages of any single test group it is sufficient to have the series of cages being tested in the same room on the same bench. This gives sufficiently uniform external conditions. The uncertainty of obtaining insects of the same

viability from week to week makes it preferable to run a fresh series of tests on any given compound when comparisons are desired. If, however, it is desired to compare one day's tests with another, it is essential that the test cages be kept in a room of uniform temperature. Such tests can be made by employing a room similar to the insectary described in a previous paper from these laboratories.[1]

It is obvious that the three check cages set up on any day may serve as controls for as large a series of test pairs as may be set up.

INTERPRETATION: If C is taken as the per cent of insects living in the feeding control cage and T is the percentage alive in the test cages, then

$$100\frac{C-T}{C} = I$$

the insecticidal coefficient of the finished insecticide and the lower the coefficient, the less effective the insecticide. To obtain the insecticidal coefficient of the insecticidal principle apart from its carrier, the equation is modified to

$$100\ \frac{S-T}{S} = I_p$$

in which S is the per cent alive in the carrier control cage, I_p the insecticidal coefficient of the insecticidal principle, and T is again the percentage living in the test cages.[2]

One method of arriving at the insecticidal value of a given compound has been outlined just above. Two others are possible.

(1) If the material being tested is a liquid it can be emulsified in water and this emulsion can be sprayed exactly as described under procedure above. Such emulsions are difficult to make with water alone as the dispersing medium so it is commonly better practice to employ an emulsifying agent. For this purpose soap solutions have proven very generally satisfactory. In such a case, however, the insecticidal action of the soap must be taken into consideration and evaluated as hereinbefore described. Tests in this laboratory indicate that saponin is a more satisfactory emulsifying agent for tests in that its effect upon insects is practically negligible. Its chemical inertness is also a desirable feature in the case of compounds possessing alkali sensitive groups. The only accessory or synergistic component in this case is water.

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[1]Studies in Breeding Insects Throughout the Year for Insecticide Tests. I. House Flies (*Musca domestica*).

[2]Effectiveness against the San Jose Scale of the Day substitutes for Liquid Lime Sulfur. Abbott, Culver and Morgan, Dept. of Agr. Bulletin No. 1371, pp. 6.

(2) For compounds which are solid or which it may be preferable to apply in powder form a different procedure is necessary. Two general methods are suggested. A group of insects (and the number should not be too small) may be placed in a can and sprinkled with the powder until enough powder is spread over the bottom of the can to make it possible to give each insect a thin coat of the powder by shaking the can about. This method insures a fair test of the insecticide but does not in any way approximate the conditions under which the insecticide is normally employed. It is the opinion of these laboratories that tests should be designed to approximate more closely the conditions under which the ultimate consumer applies the insecticide. Accordingly, the methods which have been followed here have been somewhat more rigorous.

If the insecticidal powder is designed to be sprayed or blown upon the insect, the insects are placed in the opening of a V-shaped runway which has a trap at the narrow end and the powder being tested is blown against them. They are then carefully brushed into the trap and the time required for the insecticide to produce death is observed. At the end of 24 and 48 hours the number of insects still left is counted and the efficiency of the insecticide at the expiration of these periods is calculated by the application of the formula developed above. For this test, if a diluent is employed, a check test on the diluent is also made under similar conditions to the test proper. Of course feeding and starvation checks must also be run in connection with these tests or the equation is not applicable.

If the insecticide is designed to be spread in cracks or across runways, a method has been developed which closely approximates the conditions existing in actual use. A 6 inch square of 1 inch pine is enclosed at a distance of 6 inches by a retaining wall of 1 inch strips. The bottom of the moat thus formed between the island in the center and these retaining strips is covered with a layer of the insecticide to be tested. Insects are then liberated on the island a few at a time and lured across the moat where they are captured and placed in small cages. These caged insects are counted at the end of 24 and 48 hours and the insecticidal coefficient is calculated as above.

In conclusion it must be noted that the number of insects employed in each test must not drop below the minimum of about fifty for, as we have pointed out in previous papers, the dependability of a biological test is always closely related to the number of tests run.

STUDIES IN INSECTICIDAL ACTIVITY

III. Testing Insecticidal Fumigants—i.e., Insecticides Which Function in the Vapor Phase

By C. H. Peet and A. G. Grady, *Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

An exact procedure for the testing of insecticidal fumigants for use in (A) storage warehouses and (B) grain elevators, etc., is described.

Comprehensive studies have been made by Roark and Cotton,[1] by Hoyt[2] and others upon the use of various compounds and mixtures as insect fumigants, and the authors of this paper have drawn freely upon their published work, as well as upon private communications, in developing the testing procedure advocated and described herein. It is obvious that a considerable degree of uniformity will run thru entirely independent work of this sort, but certain divergencies appear, and it is the purpose of this paper to present an easily reproducible standard method of testing which may be employed by anybody anywhere with the assurance that the results will be strictly comparable.

The use of fumigants in insect control is confined, of course, to warehouses and storehouses of various sorts, and tests to determine the effectiveness of compounds as fumigants must simulate actual conditions closely. It is impossible to make a quantitative test in a can or small box tho such a test may serve to give useful qualitative data, and the results obtained may indicate the amounts which will be required for quantitative tests. The insecticide, which is employed, must be volatile and possess the property of penetrating deeply into rather closely packed material, and in the test the insect should be given the protection lent by a layer of the material in which it would be found. The insects which are the most common warehouse pests, grain weevils and moths, should be employed in studying the value of an insecticide as a fumigant.

(A) Tests on Fumigants for Storage Warehouses, Etc.

In a chamber of not less than about 200 cubic feet capacity are placed four boxes, each containing a layer of woolen material, then a colony

[1] Jour. Econ. Entomol., *20*, 636, 1927; Jour. Ind. and Eng. Chem. *20*, 512, 1928; U. S. Department of Agriculture Bulletin No. 1313—Neifert, Cook, Roark, Tonkin, Back, Cotton—Fumigation against grain weevils with various volatile organic compounds.

[2] Jour. Ind. and Eng. Chem. *20*, 400, 1928.

of moths and larvae numbering about twenty-five, and over this firmly tamped down a top layer 4″ thick of either woolen or cotton waste. The exact size and shape of the chamber is immaterial, but it should be tight. The fumigant is introduced thru ports in such a manner that the insecticide itself does not drop upon or come in direct contact with the moth culture. With gaseous fumigants no such precaution is necessary but with volatile liquid fumigants a shield must be interposed between the spray and the moth culture, if a spray is employed. If direct volatilization from a container within the chamber is relied upon, the use of such a shield is unnecessary. The temperature of the chamber must be kept uniform in order to make successive tests comparable, and a temperature of 80° is very satisfactory. Tho the importance of humidity appears to be less marked than in the case of insecticides designed for use against flies and similar household pests, the importance of temperature control is equally great, for a fumigant increases in activity as the temperature at which it is employed rises. The concentration of fumigant in the testing chamber must be definitely known in order to make tests comparable. If all the tests are run in the same chamber, it is sufficient to know the number of grams used in each test, but for purposes of comparison it is necessary to express the concentration of the fumigant in terms of weight per volume, i.e., grams per cubic foot or such other units as may be preferred. From an economic standpoint the ratio between effective concentration and cost is significant and should undoubtedly be the final basis of comparison, but, once the effective concentration is known, each user can easily calculate this ratio for himself.

The test period adopted is twenty-four hours, because it is seldom possible to run two fumigations in one day in commercial warehouses. At the end of the test period the box of wool is removed and the insects in it are counted. The minimum concentration in grams per cubic foot which will give 100% kill is determined, and this value is called the "fumigation factor" at that temperature for the material being tested. This fumigation factor is never based upon less than two such tests for reasons which have been pointed out in previous papers.

(B) Grain Fumigation

Fumigation of grain or flour is usually carried out in elevators or in warehouses in which the material is stored in bags or in bulk. If the fumigant is lighter than air, it should be introduced at the bottom of the room which is being fumigated, and, if the fumigant is heavier than air, it should be introduced from the top. Practically, if the fumigant is

non-toxic to man and sufficiently volatile to leave no objectionable taste or odor on the material being fumigated, it is probably satisfactory simply to spray or pour it upon the grain which is being fumigated. In the case of smaller scale tests, it is a fairer measure of the insecticidal efficiency of the fumigant to employ it in its vaporized condition.

To test the value of a fumigant in destroying grain pests, a small sack about 4 x 4″, made of some very loose material such as burlap, is filled with grain (wheat or rice) containing about one hundred grain weevils. This sack is placed in a basket of grain and covered to a depth of 6″ with the grain. Four such baskets are placed in the fumigating vault and the fumigant is then introduced exactly as in the case of warehouse fumigants. The temperature is held at 80°, and the chamber is kept closed for twenty-four hours, at the end of which time the buried culture is removed and the insects counted. As in the preceding instance, the minimum concentration in grams per cubic foot which will give 100% kill is taken as the "fumigation factor" at the temperature employed, and this factor is never accepted on less than two tests, i.e., eight checks.

As a fumigant for ground grain (flour, bran, etc.), a similar sack about 3″ square, containing bran and weevils, is buried 4″ below the surface of a sack of bran, which is then tied at the neck. At the end of the twenty-four hour test period the sack is removed and the insects in the smaller sack are counted.

Where the effectiveness of the fumigant is below 100%, these testing methods do not give strictly reproducible results, but, when the concentration of any fumigant required to give 100% kill has been determined, this same concentration will uniformly give the same percentage of kill.

Attention should be drawn to the fact that the tests, herein described, are made under ideal conditions, the temperature being held constant and the chamber being airtight. As Hoyt[1] has very correctly pointed out, the conditions existing during actual fumigation are far from ideal, due to variable temperatures and, in probably even larger degree, leakage of the insecticidal fumigant. Control of these factors is of the utmost importance in determining the relative value of fumigants, but the fact that this cannot be realized practically must be recognized by users of this type of insecticide in order that the same efficiency shall not be expected in actual practice as in tests under rigid control.

[1]Jour. Ind. and Eng. Chem. *20*, 460, 1928.

STUDIES IN INSECTICIDAL ACTIVITY

IV. Testing Insecticides as Insect Repellents and Moth Killers

By C. H. Peet and A. G. Grady, *Research Laboratories, Rohm & Haas Co., Inc., Bristol, Penna.*

Abstract

Tho ants, roaches and other insects are repelled by certain substances, this paper concerns itself solely with moth-proofing and moth-killing tests. A detailed description is given of the procedure followed in testing compounds recommended for either purpose.

The utilization of repellents for the prevention of insect infestation is confined almost entirely to the proofing of materials against the attack of moths. A measure of success has attended the prevention of inroads of ants and roaches by certain substances, but there is no reasonably exact method for determining the extent to which any given repellent discourages the intrusion of these insects. It is known that some substances sprinkled or sprayed upon the runways of ants cause them to forsake these paths and the subject is one well worth further investigation. But, in order to determine the effectiveness of such a repellent, a dependable method of testing repellency must be evolved. However, the effectiveness of a moth proofer is not difficult to determine.

The material in question should be uniformly distributed over a piece of woolen goods, and the amount of repellent is calculated upon the weight of the goods. The method for determining this concentration is as follows:

The repellent, which is being employed, is dissolved to a known concentration in the proper solvent which may be water, some organic solvent or an acid or alkali. The previously weighed goods is dipped into the solvent and squeezed out until it no longer drips liquid and is hung up to dry. The decrease in the volume of the repellent solution will tell how much of the repellent has been distributed over the cloth. A few experiments make it possible to calculate quite accurately in advance just how much solvent will be taken up by a given weight of cloth and accordingly the concentration of repellent, which must be used in the solution, can be calculated.

In the case of certain moth proofing agents (we refer particularly to the alkaloids which have been recently suggested for this purpose), dipping the material will result in an action upon the material similar to dyeing, that is, an actual physico-chemical adhesion of the repellent to the fibers of the fabric. Such an action will result in exhaustion

of the bath out of proportion to the amount of solvent absorbed. In such cases the final concentration of the bath can be determined by chemical analysis and the amount absorbed must be calculated by difference. After drying, the fabric is cut up into approximately 2 inch squares and 5 larvae are placed on each of six such squares. No attention need be paid to adult moths as it is the larvae which do the damage. Each sample is put in a small flat dish upon which a screen cover is laid. At the end of 48 hours each square is examined. The only satisfactory measure of moth proofing efficiency is the absence of holes in the fabric or destruction of the pile.

The method, which we employ, is to find the minimum concentration required to prevent moth larvae from feeding. This concentration for any known substance, compared with the concentration of any other, is the relative measure of the efficiencies of the two.

The prevention of moths by the employment of substances, which give off vapors which kill moths or larvae or eggs or repel moths and larvae, is the other common method of combating these pests. The procedure used for these tests depends upon whether the material is being tested as a moth repellent or as a moth killer. In the former case, a colony of moths, larvae and eggs is placed in a can about 10 inches high by 8 inches wide, which has a wire gauze cover. Into the can are introduced six 1 inch squares of pure woolen cloth and a seventh square of cotton cloth, dipped in the material being examined, is placed in the same can. The can is then stored in an insectary or incubator and kept at 85° F. At the end of 10 days the woolen squares are examined. If they are unmarked by the inroads of the larvae, the material being tested is considered satisfactory. Search is made for fresh eggs and the number of larvae is counted to determine whether or not the material was lethal as well as repellent. In the second case, i.e., when the material is being tested as a moth killer rather than as a moth repellent, the same procedure is followed but the can is opened at the end of twenty-four hours and the reciprocal of the number of insects and larvae alive is considered the measure of the effectiveness of the insecticide.

A FOREIGN BOOK PEST ENTERS BOSTON

By RAYMOND L. TAYLOR, *Bussey Institution, Harvard University*

ABSTRACT

A tropical Anobiid, *Catorama* species, inflicted severe damage to a large shipment of books from Honolulu to Boston. Larvae have been active and have fed for at least seven weeks in Massachusetts at room temperatures, and the possibility of infestation of heated libraries throughout the city is advanced as adequate justification for a thorough carbon bisulphide treatment of the infested stock.

Since so many of the most destructive insect pests of the United States are exotic in origin, and also, since so many of these undesirable immigrants have entered the country in an unostentatious manner, the arrival, however quiet, of any foreign insect with a bad record should be of wide interest. Such an insect, a *Catorama* species, family *Anobiidae*, entered Boston, undetected, in early December, 1927.

Book pests, of which there are only a few, relatively, are usually not considered, under ordinary conditions, to cause any great injury to the libraries of the United States, and this view is, perhaps, a correct one to apply to the book Psocids, the silverfish, et al. This opinion was shared and thus it was amazing to see the condition of some 8,000 volumes, the contents of a 29 case shipment from Honolulu to N. J. Bartlett and Co., a Boston firm of booksellers. The shipment, which contained a number of rare editions and was conservatively valued at above $25,000, was extensively damaged. Help in the matter was asked and the damaged stock was inspected. When the books were unpacked, although the newspaper wrappings showed no evidences of injury, there was scarcely a volume of the collection not riddled by larval galleries and exit holes. While some of the books had but a few holes, the majority had the covers, at least, well perforated, and some of them were rendered virtually illegible throughout. It was significant that the damp books, marked by a brown mold, were comparatively immune from severe injury, and also noteworthy, that the insect showed a decided preference for the cardboard in the covers and for old, hand-made paper, rather than for modern, clay-filled and chemical-laden paper. There was remarkably little frass considering the amount of mining, and the insects which caused the injury were not readily visible. Indeed, this latter point was a mystifying feature of the problem. The books, the former library of the late Dr. William T. Brigham, Director of the Bernice Pauahi Bishop Museum, Honolulu, Hawaii, and a noted bibliophile, were in presumably perfect condition prior to boxing and storing some two to three years ago, and since all the extensive damage

had, by presumption, occurred in that interval, there should have been ample insect remains. The probable solution of this was found and will be mentioned.

A preliminary search for the cause of the destruction, after an examination of at least fifty books, yielded three living larvae and the intact bodies of two, dormant or dead, adult beetles. These latter were determined as a *Catorama* species by Mr. C. A. Frost. A review of the literature inspired the conclusion that this insect was either *C. herbarium* or *C. mexicana* and at the same time, because *C. mexicana* was not listed in Junk's Coleopterorum Catalogus nor found elsewhere, it raised the interesting point that these two species might be synonymous. Sharp in Fauna Hawaiiensis ascribes *mexicana* to Chevrolat, who likewise is credited by Gorham, in his Biologia Centrali-Americana, with the naming of *C. herbarium*. The species, *herbarium*, was first taken in Mexico. An error in transcription, once made, might easily be perpetuated indefinitely, or until the genus was revised. In any event, both of these beetles, *C. mexicana* in Hawaii and *C. herbarium* in the West Indies and Brazil, are reputed to be highly destructive to books, leather goods, upholstery, and the like.

The living *Catorama* larvae were placed in a cork-stopped glass vial and observations were made. It was learned first, that the larvae ate their dead companions, although it is impossible to state whether or not they kill each other for that purpose. The larvae also consumed the bodies of adult beetles. This cannibalistic habit, if at all general, would adequately account for the surprisingly few insects found in the books examined, in proportion to the extensive mines, and with a consideration of the probable elapsed time of two to three years. It was also found that the larvae evidently preferred the protein of their companions, and the cork of the stopper, to the hand-made paper given them for food. Perhaps the most significant fact of all, however, is that these larvae have lived at least seven weeks in Massachusetts at room temperatures of from 40 to 65 deg. F. Living larvae continued to be taken from the books of the shipment. There arose at once the serious possibility of the destruction of books in libraries which are heated in winter, should this insect be introduced. The prospect, if improbable, was sufficiently grave so that it was agreed to subject the infested shipment to a program of thorough fumigation with carbon bisulphide. It would seem a safe rule, that, in general, any immigrant insect with destructive proclivities should be regarded as dangerous, and treated as such, at least, until all of its habits are known and its potentialities duly measured.

A more complete account of the above is in process of preparation.

SOME ADDITIONAL NOTES ON THE PINE-NEEDLE MITE, *ERIOPHYES PINI* NALEPA[1]

By ERIC WALTHER[2]

ABSTRACT

A few additional items of information about this pest have now become available. The mite appears to be rather widely distributed and seems to be carried over short distances by the wind. The carriage by man of cut branches and young trees seems to account for its sudden appearance in new localities. Spraying has been fairly successful on a small scale, but careful reforestation seems to promise the only permanent cure, providing only clean young trees are planted after previous removal of all infested pines.

INTRODUCTION

In view of the growing importance of the Monterey Pine, *Pinus radiata* Don, as a timber-tree in many parts of the world it seems advisable to publish all available information about the Pine-needle Mite, even though this last may seem to be a rather unimportant and obscure pest. This very obscurity of its habits often has delayed its discovery, even though present in some cases for many years, and certainly demonstrably injurious. In submitting the following notes the writer wishes to apologize for their brevity and incompleteness, the press of other work having prevented more thorough investigations and experiments. The previous paper mentioned under footnote (1) holds good with the exceptions here given.

HOSTS

A corrected list of host-plants and their localities, as known to the writer, today stands as follows (See footnote 3):

Location:	Host-plant:	Reported by:
San Francisco, Calif.	*Pinus radiata*.	E. Walther
Golden Gate Park, Lincoln Park	" "	" "
Harding Park, Bay View Park	" "	" "
Presidio, Spring Valley Lands, etc.	" "	" "
Alameda Co., Calif.	" "	" "
Campus, University of California, Berkeley, etc.	" "	" "
Los Angeles, Elysian Park	" "	" "
Riverside, Calif.		
Near U. C. Citrus Experiment Station	" "	" "

[1]For previous article on this subject by the writer see JOURNAL OF ECONOMIC ENTOMOLOGY, December 1925.

[2]Published by permission of John McLaren, Superintendent, Golden Gate Park, San Francisco, Calif.

HOSTS (*Continued*)

Location:	Host-plant:	Reported by:
San Diego, Calif., Balboa Park	*Pinus radiata.*	W. F. Swingle
Del Mar, San Diego Co., Calif.	" *Torreyana.*	" "
Truckee, Calif.	" *Jeffreyi.*	E. P. Felt (E. Bethel)
Southeast Ohio and N. Carolina (In *Psyche*, 1921, as *Eriophyes sp.*)	" *echinata.*	B. W. Wells
Central Europe	*P. sylvestris, P. laricio, P. cembra.*	Dr. Nalepa

Near Monterey, California, where *P. radiata* is indigenous, forming extensive, pure stands, a rather cursory examination failed to show any evidence of the mites presence, all cases of leaf cast noted being due to other causes. This would indicate that some other species of pine is the original host of the mite.[3]

HABITS

It seems certain that, at least in all locations observed by the writer, the mites do not hibernate within the buds, but may be found at all times, dormant or active, within the basal sheaths of the needle-clusters. Where the winters are colder, though, this may not hold good. The galls reported to be made by this mite in Europe, in Ohio and N. Carolina and at Truckee, Calif., may also very well represent its reaction to a more severe climate, if indeed it be the same species.

DISTRIBUTION

Contrary to previously expressed hopes even quite young pine-plantations may become affected early if there are any infested trees near by. The rapidity with which young plantations become infested seems to vary, inversely, as their distance from mite-infested pines. A wind strong enough to carry green needles is apparently needed to spread the mites. Young plantings usually become first affected on the side towards the most commonly prevailing winds, providing mite-

[3]Since this was written in the early part of 1927 the writer has been able to establish the presence of the mite on the Monterey Pine, *Pinus radiata*, throughout nearly the entire natural range of that species, having found it it Monterey, Del Monte, Carmel, Pebble Beach, as well as in the stand of the species near the line between San Mateo and Santa Cruz Counties. In the latter county it was also found on indigenous trees of *Pinus attenuata* and *P. ponderosa*. In Southern California it was also noted on *P. pinea* at Pasadena and on *P. canariensis* at Santa Monica.

This very wide distribution of the mite may possibly make the sanitation and quarantine-measures suggested difficult of execution, and should cause renewed efforts to either find some practicable method of control by spraying, etc., or to perhaps discover some natural enemy capable of reducing the numbers of the pine-needle mite to the point where it shall cease to produce any serious injury.

infested pines are to be found in that direction. Where a young plantation, remote from old, infested trees becomes affected the young trees in question will often be found to have come from a nursery having one or more mite-infested pines in its vicinity.

Control

Until reforestation makes possible the real elimination of the pest some temporary control may be attained by spraying. The following figures may prove of interest; and represent the average of a large number of counts made September 17, 1927, six months after spraying once with a 6.66% Lubricating-oil emulsion.[4]

A. Unsprayed Trees: Number of needle-clusters infested	90%
Difference of infestation between older and younger needles	20%
B. Sprayed Trees: Number of needle-clusters infested	55%
Difference of infestation between older and younger needles	50%

By the older needles are meant those that grew first, at the beginning of spring, while the younger ones matured towards the end of the growing season. On an unsprayed tree the latter are almost as heavily infested as the former, even though these last became infested much sooner. The reduction in number of younger needle-clusters infested on sprayed trees is entirely due the spraying done. This conclusion is borne out by some further, incomplete, and perhaps even more promising, tests, which indicate that spraying may produce very appreciable results if begun early, before the new growth becomes infested. The application may have to be repeated, and some doubt remains whether it might not be advisable to make lighter, more numerous applications. While the 6.66% Oil-spray seems to produce very lasting effects, the oil-film remaining visible, and actively protective, for quite a long time, this heavy dosage may in the end injure the pines, perhaps as much as the mites would have done.

Summary

While it may not be impossible to check an infestation after its start by the prompt removal and destruction of all pines affected throughout the plantation and its neighborhood, the destruction of large numbers of trees is a drastic measure and represents an economic waste hard to justify, especially in view of the obscurity of the mite and the insidious nature of its work. As it remains yet to be demonstrated whether any real, lasting control of the mite may be attained by spraying it would seem wise to plant only clean young pines, grown in clean nurseries in mite-free localities, making previously sure that no mite-infested trees remain to reinfest the new plantations. The enforcement of rigid

[4] Standard Oil E. Stock, about 22° Baumè.

quarantine-measures with rigid inspection also seem essential if the further spread of the pine-needle mite is to be checked. If these precautions should prove insufficient the only alternative would appear to be the choice of some trees other than pines for reforestation (See footnote 3).

TROPIC RESPONSES OF CODLING-MOTH LARVAE

By N. E. McIndoo, *Entomologist, Deciduous-Fruit Insect Investigations, Bureau of Entomology, Washington, D. C.*

Abstract

In order to throw light on the biology of the codling moth, a thorough investigation of the tropisms of this insect was begun in the spring of 1927 at the suggestion of Dr. A. L. Quaintance in charge of Deciduous Fruit-Insect Investigations, Bureau of Entomology. Definite results were obtained by using only the larvae. In all 154 larvae, belonging to both broods, were tested individually in the laboratory under various conditions.

In bright light, although not direct sunshine, larvae of the first instar are weakly photopositive; that is, they go toward light. The following tests indicate how they find food under natural conditions. Twelve cubes of apple, each 4 or 5 millimeters in size, were placed about 1.25 inches apart on a paper inside a circle having a diameter of 5 inches. The paper lay on a table by a south window. Larvae were then placed, one at a time, inside the circle and allowed to search for the pieces of apple while slowly moving toward the light. Pieces of cork of the same size and squares drawn with a pencil inside the circle were used as controls. Larvae went to the pieces of apple 67 per cent of the chances offered them; to the pieces of cork, 50 per cent; and passed over the squares 30 per cent. These results indicate that smell and sight aid in locating objects. This method also suggested how attractants and repellents might be tested, but no definite information on this point was obtained, except that the larvae were found to be easily repelled and attracted with difficulty. Since larvae of the first instar have photopositive eyes they remain in the open and search freely for food, apparently not being aided by their sense until within a few millimeters of the food, because in the tests they wandered about aimlessly and did not perceive the pieces of apple and cork until near them, when they often turned and went directly to them.

Larvae of the second, third, and fourth instars are weakly photopositive to weak light, but indifferent to strong light. Larvae of the fifth instar sometimes act indifferently to light but generally are weakly photonegative; that is, they go away from light. Larvae of the sixth instar are either weakly or strongly photonegative, the degree depending on their age; and those with blackened ocelli did not respond to light. At cocooning time the larvae are strongly photonegative, geopositive, and thigmopositive, whereas during their earlier instars they behaved either indifferently to light, gravity, and touch, or were photopositive, geonegative, and thigmonegative. Consequently, when the larvae are ready to spin cocoons they avoid bright light as much as possible, usually move toward gravity, and hunt for dark and tight places in which to pupate. When bands are used as a supplementary control method we are merely taking advantage of nature's laws. It therefore seems that the vulnerable period in the life history of adult larvae is brought about by a change in tropisms.

(Withdrawn for publication elsewhere)

A VIAL FOR CATCHING SMALL LEAPING INSECTS

By MILTON F. CROWELL, *North East, Pa.*

ABSTRACT

By fitting a cone of fine wire screen, with an opening in the apex, into the open end of a vial, one can prevent the escape of small leaping insects caught in the vial. This is an advantage when collecting such insects alive.

A short time ago the writer had occasion to capture alive some specimens of the grape leaf-hopper, *Erythroneura comes* Say. These insects leap quickly and are difficult to catch in a vial. When in the vial they leap about vigorously, and often will escape when the vial is opened for the purpose of catching others.

The vial figured here was designed to aid the collector by allowing him to give his efforts to the capturing of the insects, and permitting him to take his attention from the matter of keeping those once caught.

A shell vial three inches long and three quarters of an inch in diameter was used. Into the open end of this was fitted a cone of fine copper screening, having an opening in the apex.

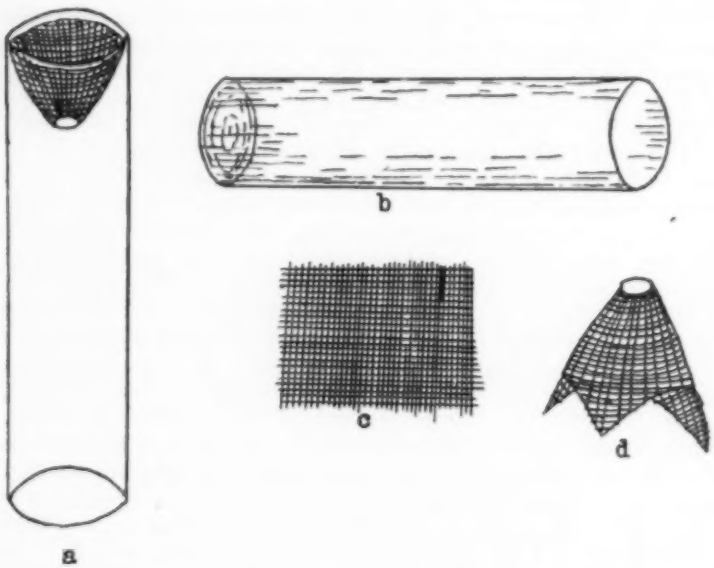

FIG. 45.—Vial for catching small hopping insects: *a*, completed vial; *b*, shell vial; *c*, small piece of screen; *d*, screen cone before fitting in vial, with corners untrimmed.

The cone was made by taking a small square of screen and forcing it into the opening of the vial by applying pressure to the center of the screen. When the cone was thus shaped, a small hole was cut in its apex. The cone was then placed in the vial again and the corners of the screen trimmed off. The cone can then be forced a little way into the vial, remaining in place by the spring action of the bent wire against the side of the glass. Care should be taken not to make the cone so small that it will drop out.

While not perfect, a few hoppers will escape even from this, this arrangement made the catching of leaf hoppers comparatively easy. The vial would be useful for such insects as flea-beetles as well.

Scientific Notes

Sexual Color Variation in *Heliothis obsoleta* Fab. So far as can be ascertained, writers on *Heliothis obsoleta* Fab. heretofore have not considered color differences in the moths of this species as specific sexual characters. That these color variations of the moth were recognized is evidenced by the fact that they have been treated as varietal characters. According to about 100 dissection records and over 1,000 oviposition observations made at Baton Rouge, Louisiana, during the fall of 1926 and 1927, all individuals formerly considered as belonging to the variety *ochracea* Ckill. were found to be females, while all those of the variety *umbrosa* Grote were males.

While individuals of both sexes may vary in degree of color as regards lightness or darkness, the sexual color remains constant. The female is always a tawny colored yellowish-brown, while the male has an olive-green tint. An excellent illustration of this sexual color differentiation is given in Kentucky Bulletin No. 187, Plate I, by Garman and Jewett. This plate shows quite clearly forms which according to our observations are a typical male and female under the legend "Color variation of *imagoes*."

Quaintance and Brues in Bulletin No. 50, Bureau of Entomology, U. S. Department of Agriculture, state: "More of the females fall in the *ochracea* group and more of the males under *umbrosa*." It appears from this statement that these color differences were not recognized as strictly sexual characters, although the authors noticed a relationship between color and sex.

The conclusions of these observations have been referred to and substantiated by Mr. Carl Heinrich and Dr. H. G. Dyar after a study of the literature on this group and the material contained in the collections of the National Museum.

C. E. SMITH and NORMAN ALLEN, *Baton Rouge, La.*

A New Method of Using Fish-oil as an Adhesive. An adaptation of the use of fish oil as an adhesive, as worked out by Hood for use in spraying with arsenate of lead for the gypsy moth, has been developed at the laboratory of the Bureau of Entomology at Vincennes, Indiana, and is here mentioned as of possible interest to other entomologists.

As now recommended, the fish-oil is poured directly into the spray tank, and is mixed with the insecticide by the action of the agitator. A more intimate mixture of the fish oil and arsenate of lead appears to be obtained by first making a paste, taking advantage of the fact that arsenate of lead, like most finely divided solids, is an effective emulsifier, and may be used to emulsify the fish oil. The following proportions have been used:

Arsenate of lead	8 lbs.
Water	14 lbs. (About 7 quarts.)
Fish oil	2 lbs. (About 1⅞ qts.)

The arsenate of lead and water are first thoroughly mixed, the fish oil is added, and the whole pumped two or three times. The arsenate of lead appears to form a very stable emulsion of the fish oil, which in this case contains approximately 33 per cent of arsenate of lead by weight. The proportions may doubtless be varied to suit the equipment used in mixing the material, although as the quantity of water is cut down it becomes increasingly difficult to force the paste through the ordinary pump.

Preliminary observations indicate that arsenate of lead prepared with fish oil in this manner has very good adhesive properties. One sample of the paste of arsenate of lead and fish oil was analyzed by the Bureau of Chemistry and Soils and showed only 0.18 per cent of water-soluble arsenic, based on the quantity of arsenate of lead present in the mixture. This seems to indicate that little or no arsenic is made water-soluble in this process.

Similar mixtures of fish oil with barium fluosilicate, potassium fluosilicate, and cryolite have also been successfully prepared, although these materials make a somewhat flocculent mixture, and are somewhat difficult to pump. The addition of a casein-and-lime spreader, ½ ounce for each pound of the insecticide, appears to result in a smoother paste.

Before measuring out these paste materials for use in the spray tank, they should be vigorously and thoroughly stirred, since the solid matter tends to settle on standing.

B. A. PORTER and R. F. SAZAMA

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

AUGUST, 1928

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $2.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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Experience in field work in both Economic Entomology and Plant Pathology has demonstrated that no one spray, spray combination or general treatment is equally adapted to all situations. In the earlier days an insect was controlled, if it succumbed to spraying, with one or another of a few standard insecticides.. To-day we are finding that plant tolerance and insect resistance are very important factors and as a consequence, research agencies are spending large sums in the search for more efficient or safer combinations for the control of various insects and plant diseases. This is reflected also in the market for insecticides and fungicides with its numerous combinations, many of great merit when properly used. There is no question but that a well-equipped chemical manufacturing company can produce a more reliable product than the private individual, especially when the latter, as is usually the case, lacks technical knowledge and is therefore compelled to follow directions which all too often may be inaccurately stated or misunderstood. There are, unfortunately, some commercial compounds where charges are disproportionate to the actual value of the materials and the cost of their combination under expert direction. This phase of the problem can not be entirely avoided, though it should be easy for most consumers to secure insecticides and fungicides through reliable agencies and thus minimize the possibilities of purchasing costly or inefficient materials. The search for better insecticides and fungicides to meet special conditions can hardly be developed to too great an extent and its vigorous prosecution means extremely valuable additions to the materials which may be used in the control of both insect pests and fungus diseases.

Obituary

J. RITZEMA BOS

Dr. J. RITZEMA BOS, of Holland, who was elected a foreign member of the American Association of Economic Entomologists at the sixth annual meeting held in Brooklyn in August, 1894, died at Wageningen, Holland, on the night of April 6–7, following a surgical operation. He was taken ill several weeks previously and removed at once to the hospital for immediate operation.

Ritzema Bos led a life of usefulness, and achieved a very high standing among the authorities on agricultural zoology and plant pathology of the world. He was born July 27, 1850, at Groningen, where he took a five-year course in agriculture and later studied at the university. He gained his doctor's degree in 1874. He was first instructor of zoology in the Agricultural College of Groningen and later in the Royal Agricultural College. In 1876 he was made Instructor in Zoology at the Government Agricultural School established at Wageningen. In 1895 he was made Director of the Phytopathologic Willie Commelin Scholten Laboratory founded in Amsterdam, and was made Professor of Plant Diseases at the University of Amsterdam. In 1899 a government phytopathological service was established for Holland, largely through his efforts, and he was made its head. In 1906 an Institute for Phytopathology was formed in the Royal University for Agriculture, Horticulture and Forestry at Wageningen, and Ritzema Bos was made Director. This institution was replaced by the Agricultural College in 1918. He reached his seventieth year in 1920, and retired, and the agricultural and horticultural world of Holland gave him a great celebration.

He was the author of many publications, but is probably best known by his "Agricultural Zoology" and his "Textbook of Zoology." Further, he wrote a work in German entitled "Zoology for Agriculturists" which passed through six editions and was republished in England. He also wrote a large volume on "Animal Foes and Friends." He wrote extensively on eelworms, and was considered an authority on this group. He was considered the father of phytopathology (within the European understanding of this word) in north Europe. He was a very lovable man and gained the respect and friendship not only of his scientific colleagues but of the agricultural public in Holland. His former student and successor, Dr. T. A. Schoevers, tells an interesting anecdote about him. He had ridden with him to a farm at Zuyden van Nijmegen. The driver was resting in a small café while Ritzema Bos and Schoevers were having refreshments. The driver was overheard to confide to the

proprietor of the café, "I have just had the most learned man in the world there in my buggy; that is the old perfester from Wageningen."

Ritzema Bos had visited America twice—the first time in 1898, when he was charged by the Netherlands government to investigate the San José scale in the United States. The last time was in 1921, when he was sent over by his government to discuss matters of plant quarantine with the people at the Department of Agriculture.

He attended many international conferences, and was well known all over Europe. I well remember the applause with which he was greeted when he entered the International Conference of Entomology and Phytopathology at Wageningen in the summer of 1923. We were very warm friends, and it is a cherished thought that the last thing written by him was an article about my seventieth birthday, which was published, the week after his death, in a Netherlands scientific journal edited by Doctor Schoevers.

L. O. HOWARD

Reviews

Leaf Mining Insects by JAMES G. NEEDHAM, STUART W. FROST and BEATRICE H. TOTHILL, pages i-viii, 1-351, 91 text figures and 3 plates. The Williams & Wilkins Company, Baltimore, 1928.

The leaf miners constitute a very interesting though not a natural group and for the most part have remained comparatively unknown because of the large number of species possessing this habit and also on account of the difficulty of rearing the adults and identifying the insects. We have in this volume a comprehensive digest of the available information concerning American species with illuminating references to the European fauna. The authors have succeeded admirably in providing an untechnical introduction to the study of leaf mining insects and in addition they have given under a systematic grouping accounts of the natural history of representatives of the different families containing leaf miners. There are numerous details which will be useful to the working ecologist. The third part of the volume is composed of lists of the leaf miners, of their food plants and of the technical papers treating of leaf miners. It is a source of regret to the reviewer that presumably space limitations made it impossible to more than list many species with references to their food plants. Many of the illustrations are original and add much to the values of the book.

The authors have rendered a very material service in bringing within the confines of one volume a digest of this widely scattered literature. It is really the history of the adaptability of various insects to special conditions and one finds among these insects numerous cases of parallel development, a phenomenon by no means restricted to the leaf miners. The list of leaf miners and of their food plants will prove especially useful to the nature student and also to the economic entomologists who are so frequently called upon to identify these insects from specimens of their work. The student of evolution and of response to environment will find much suggestive in this volume.

E. P. FELT

Current Notes

Mr. H. G. Butler, Assistant in Entomology at the Indiana Station, was appointed Assistant Entomologist at the Delaware Station, beginning April 1.

An intensive study of an outbreak of the maple leaf cutter is being made near Ottawa under the direction of Mr. J. J. de Gryse.

The Museum of Comparative Zoology at Cambridge has acquired the large private collection of Diptera amassed during the past thirty years by Mr. C. W. Johnson.

Messrs. L. H. Worthley, R. S. Clifton, H. N. Bartley, C. H. Hadley, C. W. Stockwell, and J. G. Sanders were recent visitors at the Connecticut Agricultural Experiment Station, New Haven, Conn.

According to *Science*, Dr. Carlos E. Porter of Santiago, Chili, Editor of the Rivista Chilena di Historia Naturale, has been elected president of the Entomological Society of Spain.

Mr. C. H. Griffith, of the Twin Falls, Idaho, sugar-beet leafhopper laboratory of the Bureau of Entomology, established a temporary summer substation at Corvallis, Oregon, on May 3.

Dr. J. C. Hamlin reported at the Salt Lake City Laboratory of the Bureau of Entomology on June 21, where he will assist Mr. G. I. Reeves on the alfalfa weevil project.

Mr. R. O. Malcomson, postgraduate student from the University of Illinois, spent his Easter vacation at the U. S. National Museum working up his collection of Mallophaga from Illinois birds.

Mr. W. A. Stevenson of the Tallulah laboratory of the Bureau of Entomology has returned to Arizona to continue studies on the Thurberia weevil in cultivated cotton in the Santa Cruz Valley.

According to *Science*, Mr. L. E. S. Eastham, lecturer in advanced and economic entomology at the University of Cambridge, has been appointed to represent the University at the International Congress of Entomology.

Mr. J. C. Elenore has established permanent headquarters at the Garden Grove, California, substation of the Alhambra laboratory of the Bureau of Entomology, to continue studies on the pepper weevil.

Mr. A. J. Chapman, Bureau of Entomology, who for the past two years has been in Arizona engaged in scouting and other investigations of the Thurberia weevil, has returned to Tallulah, Louisiana.

Messrs. W. J. Brown, G. H. Fisk, and J. A. Adams left Ottawa on June 11 for the Knowlton district, Quebec, where they will conduct faunal studies and collect insects for the National Collection.

Mr. A. R. Graham was recently appointed assistant entomologist in the Entomological Branch, Ottawa, Canada. He is studying forest insect parasites at the Chatham laboratory under the direction of Mr. A. B. Baird.

Mr. H. S. Barber, U. S. National Museum, went to Boston in April and spent two days comparing specimens of Coleoptera with types of Le Conte species in the Museum of Comparative Zoology.

Mr. F. F. Bondy, of the Tallulah laboratory, has been placed in charge of the cooperative work of the Bureau of Entomology and State Experiment Station, recently established in South Carolina, with headquarters at Florence.

Mr. L. Chester Marston, Jr., who graduated at Amherst, specializing in entomology under Dr. H. T. Fernald, has been selected for the Teaching Fellowship in Entomology at the University of Tennessee for the scholastic year of 1928–1929.

Airplane dusting to control the alfalfa weevil is being carried on by the University of Nevada and the United States Bureau of Entomology, according to Mr. George G. Schweis, Field Entomologist of the Nevada State Quarantine Office.

Mr. Ralph Hopping reports that the British Columbia Forestry Branch is conducting bark beetle control operations at Lorna, under the direction of the Entomological Branch, and Mr. R. Rendell is assisting in this work.

Among the recent visitors at the Japanese Beetle Laboratory, Moorestown, New Jersey, are Arthur Gibson, Dominion Entomologist, Ottawa, Canada; Drs. C. C. McDonnell and E. Wallace, Washington, D. C.; F. D. Bailey, Corvallis, Oregon; Mr. Alejandro de Mesa, Manila, P. I.

According to *Science*, Dr. Claude Fuller, formerly chief entomologist of the Union of South Africa, has left Pretoria for Lourenco Marques, where he will assume the duties of chief entomologist to the government of Mozambique.

Recent visitors at the Gipsy Moth Parasite Laboratory, Melrose Highlands, Mass., are as follows: H. L. McIntyre, Albany, N. Y.; A. B. Baird, Chatham, Ont., W. B. Cartwright, Sacramento, Calif.; F. P. Washburn, Augusta, Maine; Professor J. A. Manter and several students from Storrs, Conn.

At the recent Commencement of the University of Pittsburgh, the honorary degree of L. H. D. was conferred upon Dr. W. J. Holland, who has been a trustee of the University for forty years, during ten of which he was its chancellor.

At the June Commencement of Ohio State University, the degree of doctor of philosophy was conferred upon Mr. Louis A. Stearns, Assistant Entomologist of the Ohio Agricultural Experiment Station in charge of the Oriental Fruit Moth Laboratory at Ironton, Ohio.

At the 38th annual meeting of the Ohio Academy of Science, held at Cincinnati, April 6 and 7, Professor James S. Hine was elected president, Miss Annette F. Braun, vice-president for Zoology, and Professor Raymond C. Osburn a member of the Executive Committee.

Dr. Herbert Osborn, Research Professor, Ohio State University, by vote of the Fellows of the Entomological Society of America, has been elected an honorary fellow of the Society. Other honorary fellows are C. J. S. Bethune, J. H. Comstock, S. A. Forbes, E. A. Schwarz, and L. O. Howard.

At the invitation of Professor R. W. Harned, T. E. Holloway of the Bureau of Entomology attended a meeting of the Biology Club at A. & M. College, Mississippi, on May 9, and gave a talk on the subject "Sugar cane and sugar-cane insects."

Temporary appointments in the Bureau of Entomology are as follows: E. C. Tatman, Sanford, Fla.; C. H. Smith, Richfield, Utah; G. R. McGinnis, Corvallis, Ore.; C. C. McCall, Clyde F. Rainwater, Tallulah, La.; Paul E. Kirker, Jr., Toppenish, Wash.; C. W. Getzendauer, Alhambra, Calif.; B. J. Landis, Geneva, N. Y.

Mr. E. R. de Ong, Consulting Entomologist, and formerly of the University of California, has received the doctor's degree from Stanford University. The thesis subject was "A Study of California petroleums and their derivatives with reference to their toxicity on insects and their effects on plants."

Dr. E. A. Chapin of the U. S. National Museum left Washington on April 19 for a ten days' trip to Cincinnati and Chicago, where he visited Messrs. Charles Dury, A. B. Wolcott, and Dr. F. J. Psota for the purpose of studying types of beetles belonging to the family Cleridae.

Of the eight thousand Ascogaster parasites of the codling moth collected at Yakima in 1927 by the Bureau of Entomology, over four thousand have been distributed to other States, two lots each having been sent to Colorado and California, and one each to Oregon, New Mexico, and Arizona.

Dr. M. T. Smulyan of the Gipsy Moth Laboratory, arrived in Washington on April 13, and spent a month studying chalcids of the family Perilampidae in the Museum collection. At present Dr. Smulyan is working on a revision of the genus Perilampus in North America.

Mr. F. W. Pettey, Senior Entomologist of the Union of South Africa, is visiting the United States on behalf of the South African Government to study the work of agricultural experiment stations, and will represent South Africa at the International Congress of Entomology at Ithaca, N. Y. in August.

Mr. Herbert T. Osborn, for many years connected with the Hawaiian Sugar Planters Experiment Station and later with the United Sugars Company of Los Mochis, Mexico, has accepted a position as entomologist to a group of sugar companies in Porto Rico and is located at Central Aguirre, Porto Rico.

Mr. George S. Langford, Deputy Entomologist under Professor Gillette of Colorado and during the past year a graduate student in entomology at Ohio State University, has accepted a fellowship with the Crop Protection Institute and is engaged upon a research problem at the Ohio Experiment Station at Wooster.

Dr. Ivar Trägardh, Forest Entomologist, Stockholm, Sweden, arrived in Washington, D. C., the last week in May, and after conferring with entomologists in the Bureau of Entomology, will visit many field stations and laboratories, especially those of the Division of Forest Insects in the western and southern states.

Miss Marjorie H. Ellis, of Iowa City, Iowa, has been appointed Senior Scientific Aid in the Division of Insects, U. S. National Museum. She will assist Mr. Gahan in the work on chalcids, and will do some indexing of literature. Miss Ellis has a B. A. degree from the University of Iowa.

Owing to the satisfactory results secured in the scouting and control operations against the gipsy moth at Henrysburg, Quebec, in recent years, there will be only one crew engaged on this work during the present season. Mr. S. H. Short is in charge of the work, which was commenced on May 21.

Mr. R. Glendenning of Agassiz, B. C., is supervising the earwig control campaign at Vancouver. The work of distributing poisoned bait throughout the city was commenced on May 9. Mr. Glendenning has liberated over 200 adults of *Digonochaeta setipennis*, earwig parasites, which were imported from the Imperial Bureau of Entomology and reared at Chatham.

Professor Bernard Trouvelot of the École Nationale d' Horticulture, Versailles, France, who is now a traveling fellow of the Rockefeller Foundation, is in the United States on a trip around the world and has visited many of the field stations of the Bureau of Entomology and other entomological agencies. He is especially interested in the biological control of insects.

The newly elected officers of the Entomological Club, University of Tennessee, Knoxville, are: President, J. N. Howell; Vice-president, W. N. Moser; Secretary-Treasurer, W. R. Fyke. The Entomological Club is an active organization made up primarily of the advanced students in the Department of Entomology and the members of the faculty in the Departments of Zoology and Entomology. Meetings are held each week.

Mr. F. H. Benjamin of the Bureau of Entomology collected specimens of *Anastrepha ludens* Loew in a sour orange which he picked from a tree in Matamoros, Tamaulipas, opposite Brownsville, Texas, on May 3. A thorough search during the growth of the crop of 1927–1928 failed to reveal any infestation in the fruit growing on the Texas side of the lower Rio Grande Valley.

Professor Roger C. Smith of the Kansas State Agricultural College, Manhattan, Kansas, is on leave of absence and will serve during the coming year as entomologist in the Service Technique, at Port au Prince, Haiti. Part of his time will be spent in teaching and the remainder in research in the Experiment Station under the direction of Dr. George F. Freeman, formerly of the Kansas Agricultural College.

Mr. S. M. Dohanian, Associate Entomologist, Bureau of Entomology, who has been connected with the gipsy moth and brown-tail moth parasite work for several years, was transferred to the European corn borer activity at Arlington, Mass., on April 16. At times Mr. Dohanian has suffered considerably because of the more or less constant exposure to the hairs of the gipsy moth and the brown-tail moth, and it is hoped that the new work will be less harmful to his health.

According to *Science*, Dr. R. J. Tillyard, entomologist of Australia, and assistant J. W. Evans, are in the United States and visited the Kansas Agricultural College, Manhattan, May 19 to 22. On May 20 a special field meeting of the Kansas Entomological Society was held at the fossil beds at Elmo, Kansas. On May 21, Dr. Tillyard addressed the zoological and entomological seminar on "The Relation of the study of fossil insects to insect evolution."

Dr. R. T. Cotton of the Bureau of Entomology attended the St. Louis meetings of the American Chemical Society, April 17 and 18, and took part in the symposium on insecticides. He read a paper by Cotton and Roark entitled "Ethylene Oxide as a fumigant," and discussed another paper by the same authors, "Tests of certain aliphatic compounds as fumigants." On his return trip Dr. Cotton visited several candy-manufacturing plants in Chicago.

Mr. Leslie H. Smith of Springfield, Ill., the ingenious and daring pilot who drove the plane in the hemlock spanworm airplane dusting operations in Wisconsin in 1926, was killed in Missouri the latter part of June. He was carrying films showing scenes at the Democratic National Convention from Houston, Texas, to St. Louis, and is believed to have been struck by lightning in the air over the Ozark Mountains in a storm during the night.

Mr. Harold A. Jaynes, formerly of the Japanese Beetle Laboratory of the Bureau of Entomology, has accepted a transfer to the Division of Cereal and Forage Insects. He will conduct investigations of parasites of the sugar-cane moth borer in South America, principally in Argentina, with the object of importing into the United States such species as may be promising. It is hoped that this program will result in some control of the sugar-cane moth borer in this country.

Dr. M. D. Leonard, who has been stationed at Cornell during the past year in connection with the corn borer campaign in New York State, has accepted a position to spend about four months in the principal apple-growing sections of the Northwest. He left Ithaca about July 1 on this work and will act as special investigator on codling moth control for the Tobacco By-Products and Chemical Corporation of Louisville, Kentucky. Dr. Leonard's address until further notice will be care of Professor C. R. Crosby, College of Agriculture, Ithaca, N. Y.

The following entomologists have recently visited the Division of Insects, U. S. National Museum, for the study of specimens or to consult with various specialists: Dr. W. A. Riley, University of Minnesota; Dr. Grace H. Griswold, Cornell University; Dr. E. D. Ball, Sanford, Fla.; Dr. Herbert Osborn, Ohio State University; Professor Dayton Stoner and Dr. Carl J. Drake, Iowa State College; Dr. W. T. M. Forbes, Cornell University; Mr. S. E. Cassino, Salem, Mass.; Mr. Alan S. Nicolay, Upper Montclair, N. J.; Dr. Frank J. Psota, Chicago, Ill.; Dr. Edwyn P. Reed, Valparaiso, Chile; Dr. D. M. De Long, Ohio State University; Mr. C. A. Thomas, Pennsylvania State College, Dr. Ivar Trägardh, Stockholm, Sweden.

The conference of the North-Central States Entomologists was held in Rebstock Hall, Washington University, St. Louis, Mo., on March 1 to 3, and was favored by having in attendance more working entomologists than have been at any previous conference of entomologists of the North-Central States. The Bureaus of Entomology and Chemistry, and the States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin were represented. At the noon recess on March 1, all who were in attendance at that time motored to the U. S. Entomological Laboratory, 527 Ivanhoe Place, Webster Groves, Mo., where the investigation of corn billbugs is the special project.

Dr. J. M. Swaine, Entomological Branch, reports that airplane dusting experiments against the spruce budworm are now in progress in the vicinity of Westree, Ontario. This work is being conducted under the direction of the Division of Forest Insects with the co-operation of the Dominion Air Service, the Ontario Department of Lands and Forests and the Spanish River Pulp and Paper Company. Messrs. Swaine, M. B. Dunn, E. B. Watson, A. H. MacAndrews, H. S. Fleming, and Flying Officer Bath are taking part in the experiments. It is planned to conduct airplane dusting work against the hemlock looper in the Muskoka lake region, Ontario, later in the season with the co-operation of the Ontario Department of Lands and Forests.

The eleventh annual meeting of the Northwest Association of Horticulturists, Entomologists and Plant Pathologists was held at the University of British Columbia, Vancouver, British Columbia, and at Victoria, British Columbia, June 25 to 28, 1928. A number of papers were given on entomological subjects of interest to those working in the Pacific Northwest. The entomologists attending this meeting were: Leroy Childs and Jos. Wilcox, Oregon Experiment Station; Dr. R. L. Webster and

A. Spuler, Washington Experiment Station; W. Downes, E. Hearle, E. P. Venables, A. A. Dennys, G. R. Hopping, Ralph Hopping, Max Ruhman, R. Glendenning, R. Buckell, Entomological Branch, Department of Agriculture, Dominion of Canada; F. H. Shirck, K. E. Gibson, L. P. Rockwood, M. A. Yothers, E. J. Newcomer, U. S. Bureau of Entomology. The officers elected for 1929 are: Dr. C. W. Hungerford, president; W. Downes, vice-president; F. M. Harrington, secretary. The twelfth annual meeting will be held at Bozeman, Montana, June 24 to June 26, 1929.

Dr. Alvah Peterson of the Bureau of Entomology has been elected to a professorship in the Department of Zoology and Entomology of the Ohio State University, effective with the opening of the school year this fall. He will give particular attention to the development of instruction and research in the biological control of insect pests. With this addition to the entomological staff the Ohio State University will offer a new course especially intended to develop the possibilities in insect control by means of such biological factors as predaceous and parasitic insects and the entomophagus and bacterial diseases affecting insects. Dr. DeLong will continue his work in courses in insect control with emphasis on the chemical and mechanical factors. Dr. Kennedy's major attention will continue in morphology and ecology and Dr. Herbert Osborn as research professor will have charge of graduate research in his special fields connected with the taxonomy and biology of insects.

Apicultural Notes

Everett Oertel was granted the degree of doctor of philosophy for major work in apiculture at the recent commencement at Cornell University.

Recent visitors at the Bee Culture Laboratory included Professor A. G. Ruggles of the University of Minnesota, St. Paul, and Mr. J. C. Dods of Kansas City, Mo.

Professor George H. Rea has resigned as extension specialist in beekeeping at the New York State Agricultural College, Ithaca, N. Y., to engage in honey production and queen rearing at Reynoldsville.

The North Dakota Beekeepers Association held a summer meeting at Lisbon, N. D., on June 27. The principal speakers were Professors Francis Jager and J. W. Thompson of the University of Minnesota.

Mr. James I. Hambleton of the Bee Culture Laboratory of the Bureau of Entomology, gave an illustrated talk on the life and habits of the honeybee at the Washington Club, Washington, D. C., on May 29.

Mr. A. C. Gould, last year fellow in biology at Cornell University, has been appointed to take charge of the apiary inspection for New York under the Bureau of Plant Industry at Albany, effective June 1.

Dr. Carlton E. Burnside of the Bee Culture Laboratory of the Bureau of Entomology, went to Leesburg, Virginia, on May 19 to examine a number of apiaries where abnormal death of adult bees had been reported.

The East Tennessee Beekeepers Association held a session on May 16 at Knoxville. There was a full attendance and an interesting program. Two all-day field meetings have been arranged for during the coming summer, one near Chattanooga, the other near Johnson City.

Mr. J. E. Eckert of the Intermountain Bee Culture Field Station, Laramie, Wyoming, has just returned from a trip to Lander, Wyoming, and Fromberg, Montana, where the Station has established temporary experimental apiaries. He reports winter losses to be somewhat above the average.

Mr. W. L. Walling, State Apiary Inspector of Tennessee, has just returned from his first inspection trip over the State and reports that the bees have wintered well and are at this time strong and bringing in abundant nectar. Mr. Walling began his second inspection trip on May 28.

Mr. B. A. Slocum, who has been taking graduate work in apiculture during the past year at Cornell University, has been appointed extension specialist in apiculture for New York, effective June 1. Mr. Slocum was extension specialist in this field in Washington State College for over six years before coming to Cornell.

Dr. H. E. Barnard, President of the American Honey Institute, Indianapolis, Indiana, conferred with officials of the Departments of Agriculture and Commerce during the week of June 18 concerning the activities of his organization. The American Honey Institute, whose primary purpose is to increase the sale of honey through educational means, is financed by the Bee Industries Association of America, which s composed of the principal manufacturers of beekeepers' supplies, honey bottlers, etc.

Mr. Dwight K. Grady, Secretary of the Dried Fruit Association of California, exporters of honey, conferred with Mr. R. R. Pailthorp and Mr. H. J. Clay, of the Bureau of Agricultural Economics, and Mr. James I. Hambleton, of the Bee Culture Laboratory of the Bureau of Entomology, on May 19, to discuss certain proposed changes in the color divisions of the United States grades for honey. The general outcome of the conference was that changes in the present grades are not needed nor particularly desirable at this time.

Mr. Walter M. Scott, Service Director of the Munsell Color Company Inc., Baltimore, Maryland, visited the Bee Culture Laboratory on June 27 to confer with the members of the staff concerning the future manufacture of the Pfund honey grader, which has been taken over by this company. The Munsell Color Company is working on an attachment for the grader which will make it possible to determine the degree of cloudiness in honey without interfering with the color readings, and is also perfecting a standard daylight lamp to be used with the grader.

Mr. E. L. Sechrist of the Bee Culture Laboratory and Mr. R. S. Kifer of the Bureau of Agricultural Economics, who are now making a survey of the cost of honey production and methods of management in the intermountain States, report that the beekeepers in those states are giving them fine co-operation in securing data. Mr. D. H. Hillman, State Inspector of Apiaries for Utah, one of the co-operators, who was assisting in the cost of honey production study, recently fell while doing inspection work and was quite severely injured.

Mr. James I. Hambleton of the Bee Culture Laboratory spent the early part of the week of June 4 in Baton Rouge, Louisiana, completing final arrangements for the establishment of the bee-culture field station authorized by the last session of Congress. The station will be established in connection with the University of Louisiana, which has offered the Bureau of Entomology laboratory quarters, heat, light, janitor services, and also certain funds for the purchase of equipment. The work started shortly after the first of July, with Mr. W. J. Nolan, of the Washington office, temporarily in charge.

An effort is being made to modify the limits of the color grades for extracted honey recently established by the Department of Agriculture, as the result of investigations by the Bureaus of Entomology and Agricultural Economics. The name of the American Honey Producers League is being used in this effort to modify the grades, although the League has taken no action on the question. Beekeepers of New York State are especially active in opposing this change, since the finest clover honey under the proposed grades would be compelled to carry a name indicating inferiority. Beekeepers of other parts of the clover region and of other beekeeping regions are also opposing this movement, which had its origin with certain western honey buyers.

Mr. James I. Hambleton of the Bee Culture Laboratory of the Bureau of Entomology, was invited to be present at the oral examination on May 28 of Mr. Lloyd M. Bertholf for the degree of Doctor of Philosophy in zoology at the Johns Hopkins University. His major problem for his degree work has been the response of the honeybee to light. Mr. Bertholf has held a temporary appointment at the Bee Culture Laboratory during the last few summers. While at the University Mr. Hambleton conferred with Dr. A. H. Pfund concerning improvements in the Pfund honey grader, which was adopted in 1925 as the official color grader of the United States Department of Agriculture. Mr. Hambleton also conferred with Dr. Raymond Pearl in connection with the biometrical studies being made at the Bee Culture Laboratory.

The so-called corn sugar bills which were introduced in both houses of Congress in January were not called to hearings, largely because of the opposition of beekeepers of all parts of the country. The beekeepers prevented the passage of similar bills in the 69th Congress. The present bills would authorize the addition of dextrose (corn sugar) to any manufactured or prepared food without declaration of its presence on the label. Since the present Foods and Drugs Act has so greatly stimulated beekeeping in this country, beekeepers are opposed to any modification which will destroy this beneficial law. Other powerful organizations of producers and manufacturers of food are joining the beekeepers in the opposition. Arrangements have been made to have almost every organization of beekeepers in the country represented at Washington in the event that hearings are ever called.

On the Monday following the close of the Fourth International Congress of Entomology at Cornell University, August 20, the Empire State Federation of Beekeepers' Societies will hold its annual summer meeting and picnic at the home of Mr. E. L. Lane, Trumansburg, about twelve miles from Ithaca. The purpose of holding this meeting at this time and place is so that persons attending the Congress who are interested in apiculture may have an opportunity to meet prominent New York beekeepers. On the following day, Tuesday, visits will be made to a series of commercial apiaries in the region, and on Wednesday the Western New York Honey Producers' Association will hold its annual summer meeting, in the hope that the visiting specialists in apiculture may still remain in the State for that meeting. Traveling accommodations will be provided for those who can remain.

Miss Winifred S. Hull, a medical student of Johns Hopkins University, Miss Mary Louise Crossman, who has just received her master's degree at the University of Michigan, and Mr. Ralph K. Day, a graduate student of the California Institute of Technology, have been appointed temporary field assistants of the Bee Culture Laboratory of the Bureau of Entomology. Miss Hull is to assist in the diagnosis of

bee diseases, and to examine samples of adult bees to determine whether the Isle of Wight disease is present in the United States. Miss Crossman was employed at the Bee Culture Laboratory last summer and has been reappointed to assist in making observations in conjunction with investigations dealing with bee behavior, particularly with factors which determine the longevity of adult bees. Mr. Day is to investigate changes brought about in the color of honey due to the effect of temperature, light, age, etc.

Horticultural Inspection Notes

Mr. C. P. Daley, Junior Plant Quarantine Inspector, U. S. D. A., was transferred from Brownsville to El Paso, Texas, July 9.

The federal European corn borer quarantine was amended, effective June 1, 1928, bringing the entire State of New York within the one-generation regulated area.

Mr. A. G. Webb, Inspector in Charge at Seattle, Washington, spent the month of June inspecting special permit material in the State of California.

The federal pink bollworm quarantine was amended, effective April 25, 1928, by adding nine entire counties and parts of two others to the regulated area of Texas.

Mr. H. L. Sanford, of the Washington office, Plant Quarantine and Control Administration, spent the first three weeks in June inspecting special permit material growing in the State of Wisconsin.

Mr. Horace S. Dean, formerly employed by the Federal Horticultural Board in Washington, D. C., was reinstated June 25, and assigned to Brownsville, Texas.

The federal Japanese beetle quarantine was amended June 15, 1928, making certain changes in the requirements governing the movement of farm products from the regulated area.

Mr. L. M. Scott and Mr. J. M. R. Adams, of the Washington office, Plant Quarantine and Control Administration spent the month of June inspecting special permit material in the States of Ohio, Indiana and Illinois.

Restrictions on the importation of peaches into most of Canada have been lifted although the importation of these fruits into the Province of British Columbia from certain States is still prohibited.

L. M. Gates, Chief Nursery Inspector of the State Department of Agriculture, Lincoln, Nebr., reports as recent visitors to his office, Mr. Grady of the California Spray Chemical Co., and Mr. E. L. Chambers, State Entomologist of Wisconsin.

Mr. Allison O. Plummer, a graduate of the University of Illinois and recently employed as a nursery inspector in the State of Illinois, was appointed Junior Plant Quarantine Inspector July 2, and assigned to duty at New York, N. Y.

Mr. William J. Douglass, a graduate of Clemson College, South Carolina, and recently employed under the Thurberia Weevil project, was appointed Junior Plant Quarantine Inspector July 2, and assigned to the port of Douglas, Ariz.

Mr. B. D. Van Buren, Chief of the Bureau of Plant Industry of the New York Department of Agriculture and Markets, was in Washington June 27 and 28 con-

ferring with members of the Plant Quarantine and Control Administration regarding the Woodgate rust problem and the white pine blister rust quarantine.

Mr. J. C. Moser, formerly of the Federal Horticultural Board, employed for port inspection work in New York City, has accepted a position as nursery inspector for the State of Tennessee. Mr. Moser began his new work July 1 and will work out of the office of the State Entomologist, G. M. Bentley, Knoxville.

Recent circulars relating to restrictions on the importation of certain products have been issued by the Federal Horticultural Board as follows: HB-213—"Entry of Narcissus Bulbs for Propagation in the Fall of 1928;" HB-215—"Conditions Governing the Entry of European Chestnuts Shipping Season 1928–29," and HB-216—"Conditions Governing Entry of Bananas."

A revision of the federal narcissus bulb quarantine governing the interstate movement of these bulbs in the United States was issued April 9, 1928, and became effective May 15, 1928. The changes relate to the certification of bulbs forced in greenhouses, treatments required for bulb-fly infested plantings, and forms of shipping certificates.

Mr. George G. Schweis, Field Entomologist in the State Quarantine Office, Reno, Nev., reports that every bundle of nursery stock shipped into Nevada must now be inspected immediately prior to shipment into that State. Blanket certificates showing inspection of the plants some months previous are no longer acceptable. Nursery stock not accompanied by a certificate of inspection as indicated will be returned to the point of origin or destroyed.

On June 27, a public hearing was held to consider quarantining the State of New York on account of the Woodgate rust on Scotch pine. An outline of the life history, present distribution and economic importance of the disease was presented by Dr. H. H. York, Pathologist of the New York Conservation Commission, and collaborator of the Bureau of Plant Industry of the U. S. Department of Agriculture, who is in charge of experimental work on this disease at Woodgate, N. Y.

A public conference to consider the advisability of placing further restrictions on the importation of fruit and rose stocks or any classes of them was held in Room 43 of the New National Museum, Washington, D. C., June 27, at 10 a. m., under the chairmanship of Dr. C. L. Marlatt of the Federal Horticultural Board. There was a representative attendance of growers and users of fruit and rose stocks, of State quarantine and inspection officers and of departmental employees.

Edward Dickey, Chief of the Division of Horticulture of the Montana Department of Agriculture, Labor and Industry, reports that white pine blister rust control operations are being carried on in the vicinity of Haugen, Mont., where seedling white pine and spruce are propagated for reforestry plantings in western districts. The chemical process of eradication is employed.

Messrs. E. B. Boyd and B. T. Jones, of Chicago, are acting as publishers of a series of quarantine circulars used by about two hundred of the leading railroad and steamship companies of the United States. Quarantines relating to the movement of live stock and of horticultural and agricultural products, whether issued by the U. S. Department of Agriculture or by the various State officers are given in this series of circulars, new issues of which appear from time to time. Those parts of quarantines which apply to transportation companies are printed in full. State

quarantine officers are requested to supply copies of all new regulations of this class to the firm named in order that the railroads concerned may be promptly informed.

On May 10, Mexico issued a quarantine prohibiting the importation into that country of banana plants and parts thereof from foreign countries. This is Exterior Quarantine No. 7 issued by the Secretaria de Agricultura y Fomento. Other quarantines relating to the citrus canker, the coffee bean borer, the pink bollworm, the potato wart disease, the potato tuber moth, the Mediterranean fruit fly, and seed and paddy rice, have been issued. The plant quarantine work of that country has been reorganized during the past year and Mr. E. Coppel Rivas has been placed in charge under the direction of Dr. Alfonso Dampf, Chief Entomologist of the Mexican Department of Agriculture.

An amendment to the Plant Quarantine Act passed Congress in April and was approved May 1, 1928, giving employees of the Department of Agriculture authority to "stop and without warrant to inspect, search and examine [any] person, vehicle, receptacle, boat, ship or vessel [moving into the United States or interestate with quarantined articles] and to seize, destroy or otherwise dispose of such nursery stock, plant, plant products or other articles, found to be moving or to have been moved in interstate commerce or to have been brought into the United States in violation of this Act or of such quarantine or order."

The third annual joint meeting of the Federal Horticultural Board and the National Plant Board was held June 26, at Washington, D. C. Those in attendance were: Dr. C. L. Marlatt, and Messrs. J. E. Graf, M. B. Waite, E. R. Sasscer, S. B. Fracker, and S. A. Rohwer of the staff of the Federal Horticultural Board, and Messrs. L. A. Strong, Wm. Newell, W. A. McCubbin, W. C. O'Kane, R. E. McDonald, A. G. Ruggles, Geo. A. Dean and M. L. Dean, members of the National Plant Board. The National Plant Board held additional sessions at the Harrington Hotel, Washington, D. C., on June 25, 26 and 27.

Under the Act making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1929, and for other purposes, approved May 16, 1928, the functions of the Federal Horticultural Board beginning July 1, 1928, devolve upon and will be exercised by the Plant Quarantine and Control Administration. The field work connected with the control and prevention of spread of the gipsy and brown-tail moths, the European corn borer, the Japanese beetle and the Mexican fruit worm were at the same time transferred from the Bureau of Entomology to the latter Administration and the white pine blister rust quarantine operations were transferred from the Bureau of Plant Industry. Dr. C. L. Marlatt, Chief of the Bureau of Entomology, has been appointed Chief of the Plant Quarantine and Control Administration, and Mr. S. A. Rohwer has been made Assistant Chief.

The Federal Horticultural Board, on June 27, held a public conference for the purpose of considering the advisability of making certain modifications in the requirements governing the interstate movement of five-leafed pines and currant and gooseberry plants under the white pine blister rust quarantine. Among the proposals discussed were the desirability of permitting the wider movement of five-leafed pines from the generally infected areas of New York and the New England States into more lightly infected States when such pines have been raised from seed in a nursery surrounded by a Ribes-free zone; the discontinuance of environs inspection and federal permits for the movement of currant and gooseberry plants from the infected

States; and authorization of the movement of cultivated red and white and mountain current and cultivated gooseberry plants interstate from infected States when they have been dipped in lime sulphur solution of specified strength, maintain certain required conditions as to dormancy and defoliation, and are shipped during certain less hazardous periods of the year.

Two cases of general interest to quarantine officers were decided in the District Court of the United States for the District of Arizona in March, when the judge lifted an injunction against the Secretary of Agriculture affecting movement of cotton from that part of the Thurberia-weevil regulated territory known as the Postvale area. These cases have been pending since November 15, 1926. The court decided that "The Act of Congress having conferred upon the Secretary of Agriculture the power and duty to find facts and determine conditions upon which the operation of the statute depends, such findings and determination can not be judicially reviewed in the absence of a showing that he acted arbitrarily or unfairly, or that there was no evidence to support such finding and determination." The plaintiff's application (1) that the Secretary of Agriculture be enjoined from the enforcement of the quarantine regulations, and (2) that the Southern Pacific be enjoined from refusing to receive and ship his cotton and cottonseed without compliance with said quarantine order and the regulations thereunder with respect to fumigation and sterilization, were both denied, and judgment entered for the defendants—the Secretary of Agriculture and the railroad company.

On May 12, the California Department of Agriculture issued a revision of the State Oriental Fruit Moth Quarantine. Under the revision, any and all varieties and species including the flowering forms, of peach, nectarine, almond, apricot, plum, cherry, choke-cherry, quince, pear and apple trees or plants or parts thereof, including the fresh fruits, and all boxes, barrels, baskets or other used containers of these fruits, arriving in California from the States of New York, Connecticut, New Jersey, Pennsylvania, Kentucky, Maryland, Delaware, West Virginia, Virginia, Tennessee, North Carolina, South Carolina, Florida, Georgia, Alabama, Mississippi, Louisiana, Arkansas, Texas, Ohio and Indiana, and the District of Columbia, will be refused admittance into the State of California.

Notes on Medical Entomology

Mr. Eric Hearle was transferred to the laboratory at Kamloops, B. C. from Indian Head, Sask., early in May to investigate livestock insect pests in British Columbia.

Mr. J. L. Webb of the Bureau of Entomology, visited the Marine Barracks at Quantico, Va., on April 20, to make a preliminary survey of the situation there regarding house flies. Some co-operative control work against them is planned, to be carried out during the present season.

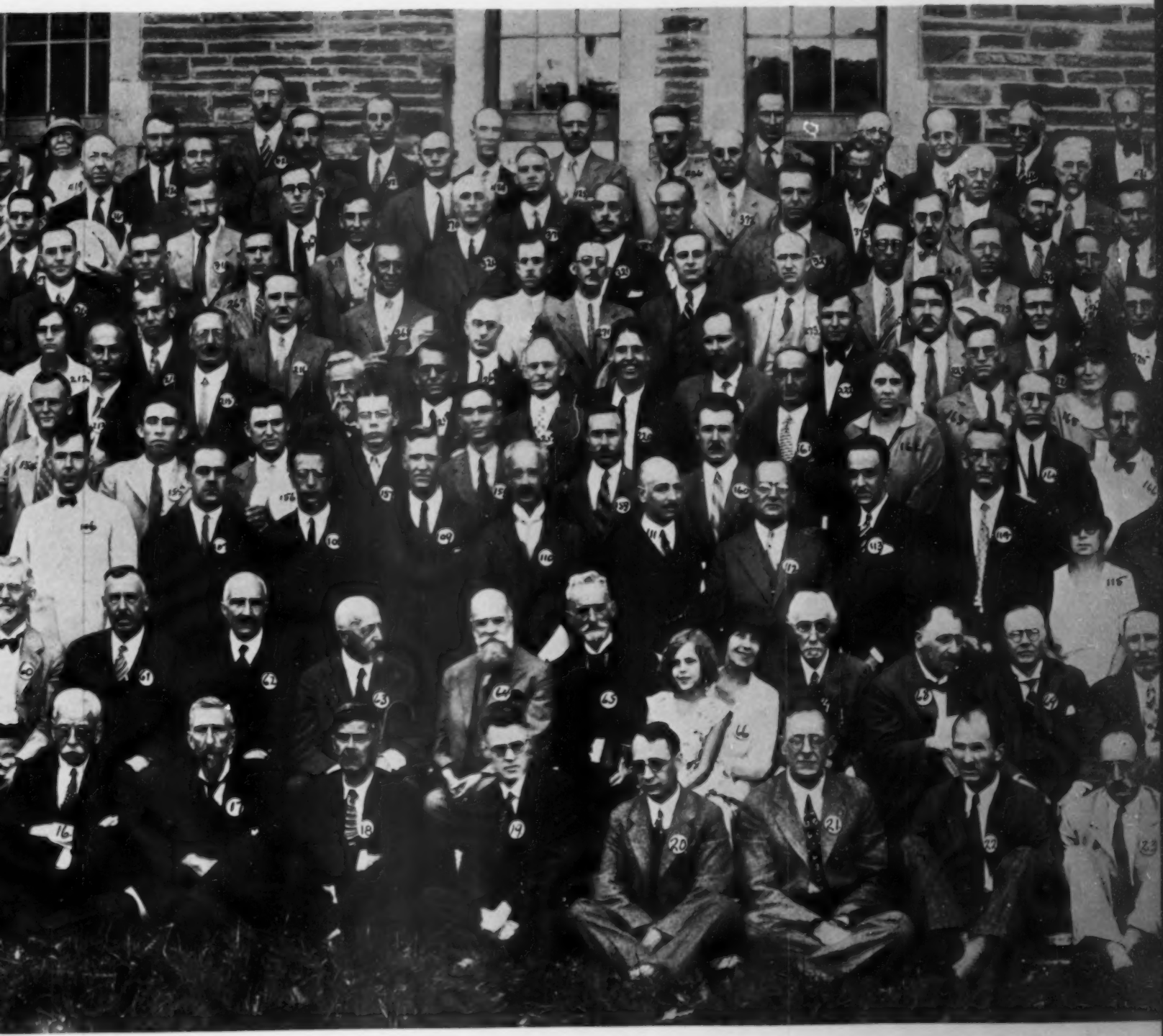
Dr. Alfred E. Cameron, Professor of Zoology and Entomology in the University of Saskatchewan, Canada, has been appointed Medical Entomologist in the University of Edinburgh, Scotland. Dr. Cameron left Saskatchewan at the end of July and will take over his new duties in succession to Dr. W. S. Patten on October 1.

During the last week of April, Messrs. G. H. Bradley and T. E. McNeel of the Mound, La., laboratory of the Bureau of Entomology, made a brief survey of the

region around Charleston, Miss., where a severe outbreak of buffalo gnats occurred. About 100 horses and mules were found to have been killed in that vicinity by the gnats.

At the urgent request of farmers and ranchmen in the Coachella Valley, California, D. C. Parman of the Bureau of Entomology spent the greater part of April studying the gnats (Hippelates) in this valley and in the Imperial Valley. These gnats have assumed major importance because of the annoyance they cause man, and almost certainly serve as important carriers of various eye diseases, including trachoma. Since Dr. Herms and Professor Woodworth have been studying the breeding habits and other phases of the problem, Mr. Parman devoted his attention entirely to preliminary observations on the chemotropic responses of the insects and the development of a trap for the purpose of catching them. A trap was devised which caught millions of the gnats and attracted much attention. In connection with this trip, Mr. Parman studied the screw-worm situation at various points in the western parts of Texas and in New Mexico and Arizona.

TROY STUDIO - 1928



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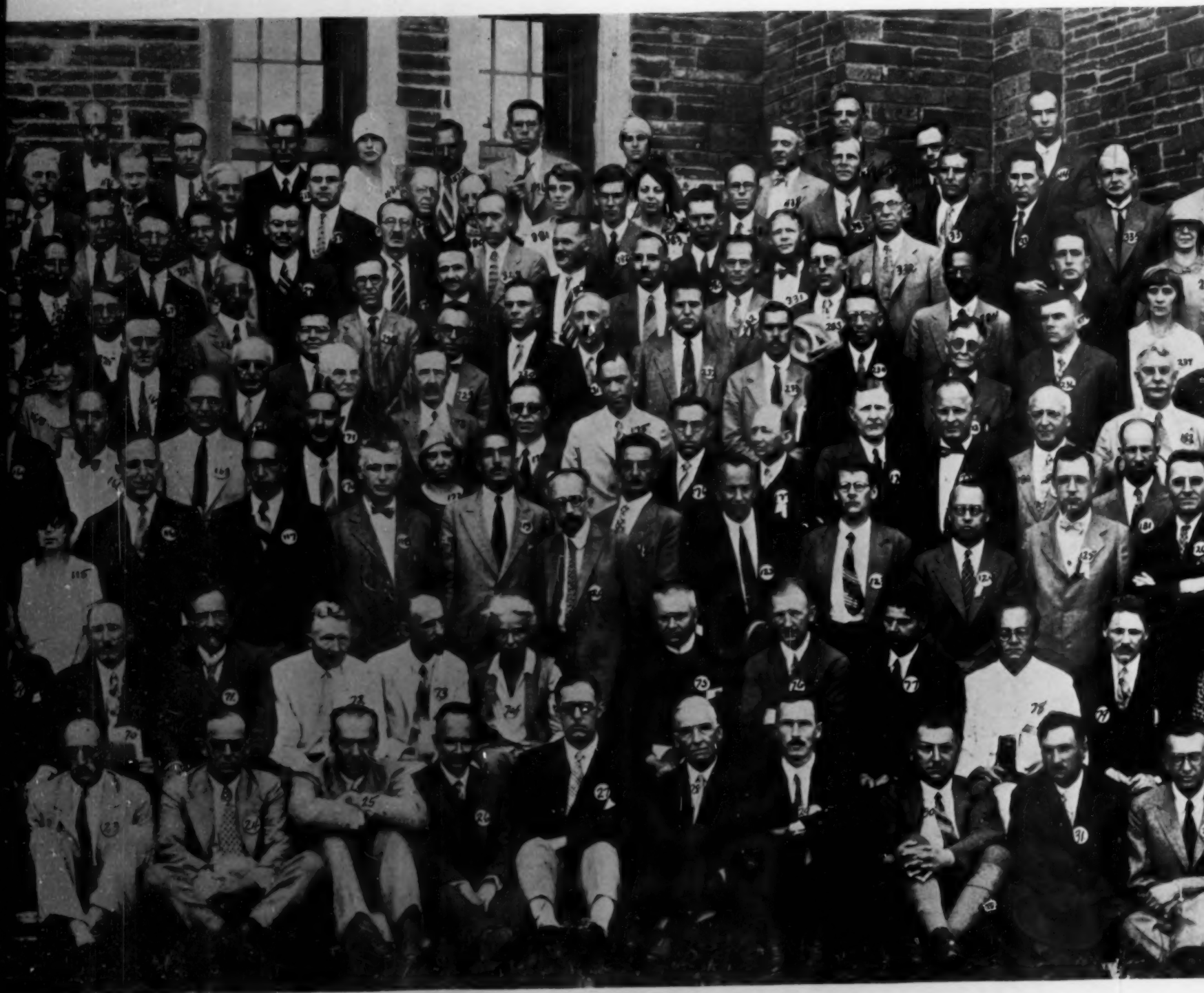

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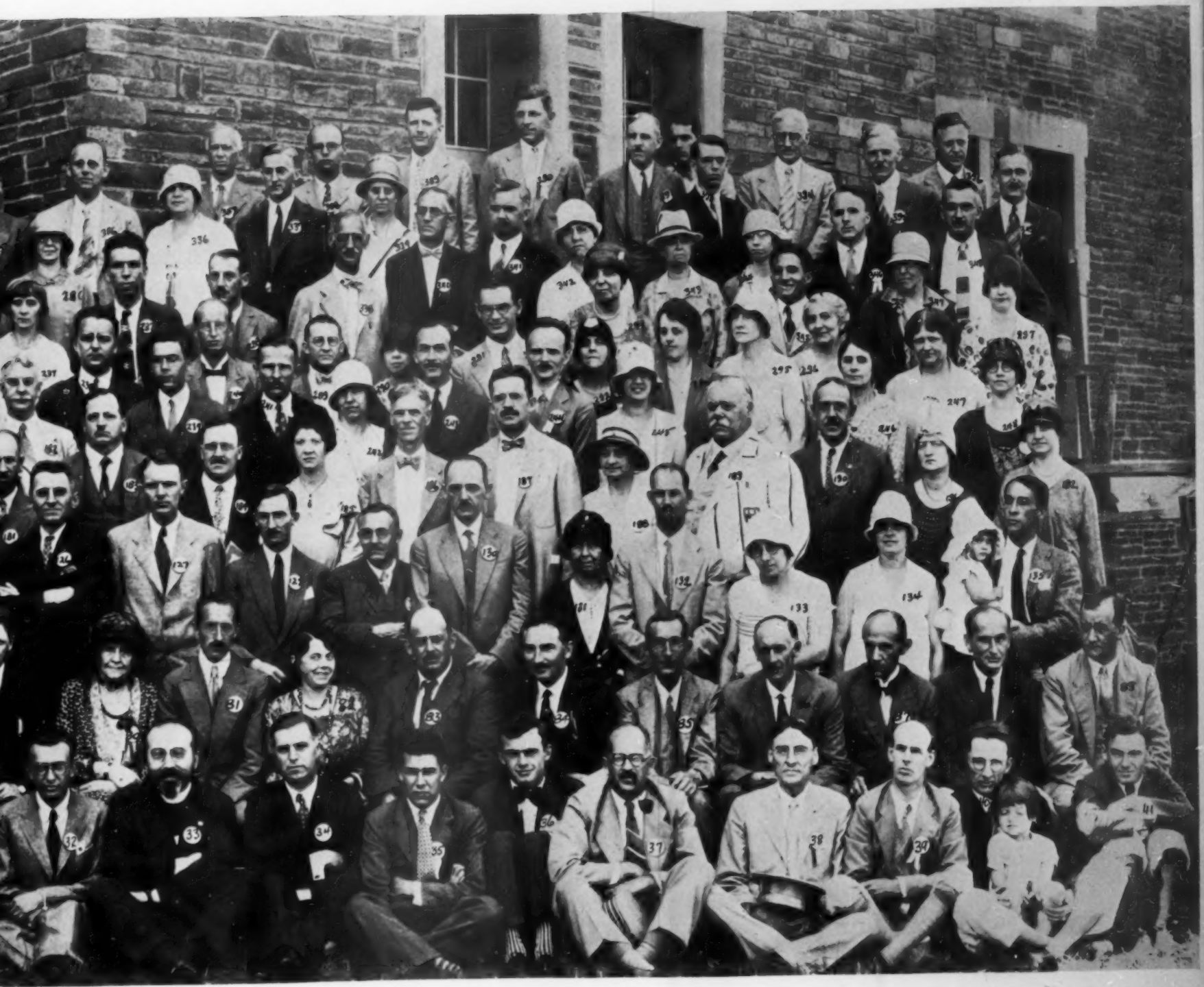

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2. G. Stewart Walley
3. Sara L. Harris
4. Eva M. Tully
5. John H. Gerould
6. William G. Lebowitz
7. Dr. Max Poser
8. A. B. Wells
9. F. L. Gambrell
10. Rodney Cecil
11. Birely J. Landis
12. J. R. Parker
13. Yeshwantras P. Bhosale
14. H. C. Huckett
15. Theo. H. Eaton, Jr.
16. W. J. Holland
17. M. Cameron
18. I. P. Kryger
19. W. H. Brittain
20. A. B. Baird
21. C. H. Popenoe
22. E. G. Smyth
23. N. F. Howard
24. R. E. Mackie
25. William Tyson
26. Fritz Stellwaag
27. H. Eidmann
28. C. L. Marlatt
29. A. Dampf
30. K. Baunacke
31. W. Knechtel
32. J. Samal
33. Rev. J. Assmuth
34. G. C. Crampton
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44. W. W. Alpatov
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56. V. Bayonnet
57. A. d'Orchymont
58. L. d'Orchymont (Miss)
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61. W. M. Wheeler
62. F. Silvestri
63. L. O. Howard
64. Karl Jordan
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68. A. G. Böving
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70. A. B. Martynov
71. G. Enderlein
72. Richard Bledowsky
73. Walter Roepke
74. Elizabeth Skwarra
75. R. Streda
76. Max Dingler
77. P. Tshorbadjiev
78. F. Rambousek
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80. A. B. Comstock
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82. Mme. Regnier
83. R. Jeannel
84. R. Regnier
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322. George I. Reeves
323. Stanley E. Flanders
324. R. G. Schmieder
325. C. R. Cu[illegible]right
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400. A. L. Melander
401. Mrs. A. L. Melander
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403. H. L. Parten
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406. Seymour Hadwen.
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409. J. L. Horsfall
410. Ann Morgan
411. Miss Cattell
412. Jacques Cattell
413. A. E. Stene
414. J. McK. Cattell
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416. William H. Gurney
417. C. S. Thompson
418. Carryl Parker Haskins
419. Mrs. Carryl P. Haskins
420. Curtis Benton
421. G. Maheux
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435. A. W. Baker
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437. Mrs. Herbert Ruckes
438. H. J. Quayle
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440. B. A. Porter
441. P. G. Mundinger